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# AIRCRAFT IN WAR AND COMMERCE

BY W. H. BERRY

A SQUADRON OF ALLIED AIRCRAFT ON A "STRAFING" EXPEDITION OVER THE ENEMY'S LINES

# AIRCRAFT IN WAR AND COMMERCE

BY

W. H. BERRY

WITH A FOREWORD BY

LORD MONTAGU OF BEAULIEU, C.S.I.

ILLUSTRATED



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# A FOREWORD

*By Lord Montagu of Beaulieu, C.S.I.*

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## THE FUTURE OF AIRCRAFT CONSTRUCTION

THERE are some who think that the airship is going to be entirely superseded by the aeroplane, and others who deny that there is any function that the airship performs to-day which the aeroplane cannot equally well carry out. I am not inclined to agree with such a view. For Naval work, at any rate, the airship must always be useful, for here it is not a question of speed in going from place to place, but of hovering for many hours in the air for reconnaissance purposes, and assuming that airships can always be protected by fighting aeroplanes as scouts, there is no reason why every Fleet should not possess its own airships, and save the wear and tear of ships, men and material in carrying out reconnaissance. I am still a believer, therefore, in the airship for Naval work.

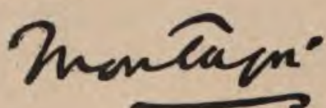


I am a believer also, after the war, in airships for commercial work, and, to a limited degree, for military work. The ability of the airship to undertake voyages of 2,000 to 3,000 miles without any petrol being expended on resisting the force of gravity must make the airship superior in some cases to the aeroplane, especially in regard to long distances.

The present drawback of the expensiveness of airship accommodation will, I believe, be got over by movable shields and the anchoring of airships behind them, so that whichever way the wind blows the breakwater, so to speak, will always cover the nose of the airship and prevent any great pressure of wind upon it. This will help very much, for it is the airship shed rather than the airship which costs money and is difficult to build and expensive to maintain.

There are some who seem to think that the German Zeppelins have been a failure throughout, instead of which they have been of immense use to the German army, a use which we shall only learn officially after the war, and they did the Germans much good in the earlier days of the war by diverting from the Front a certain amount of men and material, owing to the outcry raised by those who were bombed at home. Indirectly, German airships and aeroplanes have both been of immense service to us in bringing home to this country the importance of air warfare and the fact that England is no longer an island in a Naval or Military sense, the Channel not being now the protection it used to be a good many years ago. Invasion, after all, is invasion, whether it takes place from the sea or from the air, and the bombardment of towns, both coastal and inland, produces the same effect on the population, whether the projectile comes from a gun or from a bomb-dropping apparatus in the air. It must be conceded, therefore, that had it not been for airships as well as aeroplanes, the Germans could not have invaded England and inflicted the casualties they have. Though these casualties are small compared with the weekly or even daily casualties at the Front, they have had some effect on the morale of the population of certain areas, especially in towns, for urban populations have more excitable temperaments than dwellers in rural areas.

Nor has the last word been said as to airships. Many improvements are likely, and it is certain that higher speeds will be attained combined with greater buoyancy and arrangements for renewing the gas in the envelope. The airship is therefore by no means obsolete, and it has, in my opinion, a considerable future.



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## CHAPTER I

### HISTORICAL

BECAUSE during the war the aeroplane has been developed to a very remarkable state of efficiency in Europe, there is a tendency to overlook the fact that it was essentially and wholly an American invention. It is not a matter of vital importance to correct any mistaken impression here, and the reference is only made because it is well that the great Republic of the United States should have whatever credit is due even now, in addition to the credit that will be awarded to the genius of two of her sons in the histories of the future.

The Great War must undoubtedly rank as one of the supreme events in the world's history, but there are not wanting those who are of the opinion that important as is the war itself, tremendous as will be its effect on the world and the lives of men, aircraft will have in the end an even greater influence. The war has cost millions of lives and very many millions of money, and it will have a direct bearing on the lives of the world's peoples for many generations to come. When it is only a memory—an additional source of annoyance for the student and the schoolboy and a field of research for the learned antiquarians—aircraft will still be one of the most potent factors in the world.

The aeroplane has come on us so suddenly and in its development has been so rapid in so few years that few imaginations are equal to the task of visualising all that its conquest means. The land and sea have for long belonged to the dominion of man. To these the dominion of the air must now be added. Aeroplanes have already flown 700 and 900 miles without need of landing for the replenishment of the fuel tanks, at a mean speed of between 65 and 80 miles per hour. These machines were built primarily for military purposes and not specially for long-distance flying. They had to carry guns and ammunition for defence against the attacks of hostile aircraft, in addition to pilots, camera and wireless sets. It is obvious, then, that if such performances are now everyday matters, as indeed they are, that so soon as designers and engineers can turn their attention to the development of the aeroplane apart from war purposes machines will be built capable of flying the Atlantic and even the Pacific. There can be no reasonable doubt of this. But as to the details of this long-distance flying, the many special landing stations that must be built, the laws of the air that must come into being, the navigation laws that must be followed, and all the thousand and one big and small problems still needing solution, problems involving science and engineering and mechanics and many other things, these are things to be treated later on in this story of aircraft.

So quickly do events move that only by an effort do we realise that this year of 1918 is only the fifteenth since the first actually controlled flight in a power-driven aeroplane was made by Orville Wright, on December 17th, 1903, at Dayton, Ohio, U.S.A. Numerous uncontrolled flights had, of course, previously been made by many experimenters and investigators in various types of gliders. But to Mr. Orville Wright—an American citizen flying an American-built machine—belongs the honour of being the first actually to control a power-driven, heavier-than-air aeroplane. The first aeroplane had many limitations; looking backwards it seems hard to find any special advantages it possessed, though it must be placed on record here that even now, when so much greater knowledge is available, the first Wright machine was, considering all things, remarkably efficient in flying and lifting powers.

News of the Wright experiments came across to Europe after a space, and although the world in its usual way ridiculed the stories and spoke slightingly of the reports, other investigators, fully aware that the problem of mechanical flight was almost automatically solved with the advent of a suitable power unit, re-doubled their exertions. Even the first tentative flights in Europe, however, were made on machines resembling in many of their features the Wright construction. When at last the brothers were persuaded to bring their aeroplane to Europe for the purpose of demonstrating and proving their claims, there were already in existence a number of other machines which had achieved actual flight, but the performance of the Wright biplane quickly put the others into the shade.

For a few months America held supremacy in the air, and in a most unaccountable way, considering the resourcefulness, the mechanical ingenuity and the farsightedness of the American nation as a whole, the invention was allowed to slip through their fingers until, in the fourth year of the Great War, the United States as an actual aerial power was not worth serious consideration. Her potential power along these lines, however, with her unlimited wealth, her accumulation of money and power during the first three years of war, and her enormous manufacturing resources, undoubtedly greater than any others in the world, were quite another thing.

The Wrights' machine embodied definite features which were exclusively the invention of the brothers, and to which the protection afforded by the patent laws of the leading countries undoubtedly have been extended. With an invention of smaller calibre, of a lesser potential influence on the world's progress, it is possible that these patent rights would have been insisted on. Now, looking backwards, it would seem that, even had the civilised nations granted the Wrights their just protection, Germany would have avoided the obligations imposed on her by her own laws and regulations, and would have neutralised the patent protections granted in other countries. In point of fact, however, the brothers very generously placed their invention at the disposal of the world in general for an absurdly-inadequate consideration.

French inventors so improved on the Wright ideas that soon aerial supremacy passed to France. The fertile brains of her engineers quickly seized on the immense potential value of the aeroplane, and development followed rapidly on development.

There were at that time no schools of aviation where intending pilots could become familiar with all the details of flight with the minimum of risk and expense. Each man taught himself to fly, and, as theories did not all agree and the machines were differently controlled—sometimes in marvellous and weird ways which the inventors themselves did not bother about explaining, being content with the fact that the machine did fly and, in the air, was more or less controllable—none of the early pilots could give much assistance to others. Fatal accidents, considering all things, were relatively few. The air itself was an unknown quantity, and the first navigators of the uncharted seas did not conjure up more extravagant bogies, none the less real because they were not based on fact, than the pioneer airmen. Wind gusts were a terror, air-pockets a nightmare; aerial eddies, whirlpools and temperature were carefully studied in theory and as carefully avoided so far as limited experience allowed, in actual flight; the modern maxim about safety being in height was unknown in practice for the simple reason that the machines could only reach heights which many a pilot to-day would regard as merely a mild flirtation with suicide.

The bulk of the early experimental work in the air was carried out under conditions which barely allowed a one per cent. margin of safety. But in a few years tremendous progress was made. Hardly ten years later Lord Montagu of Beaulieu published a small booklet called *The World's Air Routes and their Regulation,* in which he laid out actual working plans for the establishment of air lanes, traffic regulations and conditions which must govern night flying in the near future when aerial services between the great centres of the world are an established fact. This little publication bids fair to become a standard work, for every civilised Government in the world became possessed of copies, foreign newspapers and periodicals re-published portions and extracts, and numerous reviews were printed.

When actual flight had once been achieved there were three main points confronting the designer: the weight of the machine, with pilot, oil and fuel; its velocity in the air; and the power of the engine, the latter being determined very largely by the first two factors. There were dozens of other matters to be considered. Take the question of materials. Should the framework of the wings of the body be of wood or metal? If of the former, what woods would be best for particular sections, what sections, how should the struts and spars be housed, anchored, stiffened and tensioned? Metals had their own peculiar advantages, but the aeroplane builders asked more than the tube makers, to take only one case, were prepared to give. Only very limited quantities of materials were needed—a few pounds worth at the outside—and the business instincts of the metal dealers forbade them to start costly experimental work, and to lay down new plant on the off-chance of securing a fifty pound order from men who were engaged in the elusive heavier-than-air flying machine business. What was true of the tube makers was equally true of other suppliers.

The early flight enthusiasts partly solved the problem by using anything that came to hand which, by any stretch of the pioneer imagination, could be termed suitable. So far as the engines were concerned matters were vastly different. Here the aeroplane designers were almost entirely in the hands of other people, and it was quite impossible for the private experimentalist who could erect a machine complete but for the engine in a shed or tent, practically unaided if need be, to build the necessary power unit. Orders, then, had to be placed with outside constructors. Fortunately engineers as a class, and particularly those who had given attention to the extraordinary progress of the petrol engine

THE DESTRUCTION OF A SUBMARINE BY A SEAPLANE

A GERMAN SEAPLANE RETURNS TO ITS BASE

in its application to motor-cars, were enthusiastic about the future of the unit, and they could see at the worst that even if the aeroplane failed to materialise into a commercial success, the experience gained in the search for power, light weight and trustworthiness could hardly fail to benefit the car engine proper. The pioneer aeroplane builders, then, had the choice of two courses in regard to their engines. They could go to an engineer and give, along broad lines of weight, power and reliability, their ideas about the engine needed for their particular aeroplane, or, failing this, they had the choice of purchasing one of half-a-dozen makes of engine which, in the opinion of their respective designers and builders, were suitable for use in aeroplanes. Very broadly speaking this was the position of those who had great faith in the future of the heavier-than-air flying machine a few months after the Wrights arrived in Europe.

When the brothers arrived in France short flights—flights, that is, during which the machine could be to some extent controlled in the air, a feature which distinguished them from mere hops from the ground—had already been made, and a few months previously Henry Farman had flown a mile in a closed circuit. The achievement was hailed as a great historic performance—as, indeed, it was, being the first real mechanical flight of any importance to take place in Europe—but it was quite eclipsed by the Wright machine, which, after some amount of exasperating delay due to need of adjustment to petty detail, flew, piloted by Wilbur, 30 and 40 miles in single flights (August, 1908, to April, 1909) as quite a regular performance.

French designers and experimentalists were the first to pay full and graceful tribute to the work of the brothers, and then they turned to with the idea of improving the machines, either by eliminating the weak points in the Wright biplane or by developing entirely new designs.

One of the first and most important improvements was the fitting of wheels to the undercarriage or chassis of the aeroplane, in place of the construction used by the Wrights, which called for the use of a special launching platform. Wheels and better shock absorbers enabled the machine to land or take the air on or from any large-sized, level and fairly smooth ground. Then came the battle of design. Which was it to be: the monoplane, with its single pair of wings, speedy, light, but rather tricky to fly and, because at that time the elementals of construction and materials were not so well understood, more likely to collapse in the air owing to the greater load the wings were called on to support; or the biplane, slower but more stable and stronger; or the triplane, which had most of the advantages of the biplane without some of the disadvantages, but which the engine builders were unable to rise to?

Every now and again came along an inventor with a machine which seemed, for the moment, to upset all the earlier ideas. M. Santos-Dumont, for example, built and flew a little machine, fitted with a twin-cylindered engine, the total area of the main plane being only 115 square feet, and the complete aeroplane weighing, without pilot, 242 lbs., which caused an amount of surprise. Nowadays it would without doubt have been spoken of as the forerunner of an aerial Ford. The inventor got about 65 miles per hour out of it, but only one other pilot, M. Audémars, followed his example.

With increased experience problems which at first seemed almost insurmountable became simply matters of mechanical calculation. The first pilots in their desperate efforts to preserve flying balance—they had grave ideas in those days about centres of gravity, action of gauchissement, critical velocities, head resistances, and so on, things which the modern designer accepts as part of his multiplication tables—adopted a prone position when in the air. Improvements in general design soon made this unnecessary, and, after a while, the attachment of an odd hundredweight or so to any part of the machine, so long as the controls were not interfered with, made little difference to its behaviour in the air. Then some inventors thought that the tail would be better placed in front of the main planes, and others had curious ideas about "inherently stable" machines, some tried locating the pilot above the wings and others placed him below, there were attempts to secure lateral stability by fitting fins to various parts of the machines. It was a period of chop and change; much money and time was wasted, and many cranks were proved hopelessly wrong in their ideas; but there were under-currents of well-informed serious work and experiment, and, a year after the Wright brothers had demonstrated the possibilities of mechanical flight, far-seeing men were convinced of the future opening up for the aeroplane, and were prepared to give time and money to its development.

The Antoinette, Esnault-Pelterie and the Blériot monoplanes were early French machines which gave much excellent experience to their pilots and designers, and the Voisin and Farman biplanes showed the possibilities of slower type machines. M. Blériot flew across the English Channel on July 25th, 1909, in a Blériot monoplane fitted with a three-cylindered 22-28 h. p. air-cooled Anzani engine, but the biggest step forward since the Wright invention was the production of the rotary, air-cooled engine which, though extravagant in fuel and lubricating oil, developed far more power, weight for weight, than any other engine previously tried. Many good designs of aeroplane had, before the advent of the Gnôme rotary engine, remained on the ground because there was no engine light and powerful enough to take them into the air. After the world-famous meeting at Reims, in August, 1909, all this was changed. Pilots began to spend hours instead of minutes in the air, and the available knowledge of flying grew daily. Here is the evidence thereof. On the last day of 1908 the distance record of 77 miles was held by Wilbur Wright. In August of the following year the record went to Henry Farman, who, using a Gnôme engine, covered 112, increased, about two months later, to 150 miles. For two years afterwards practically all the records were made by machines using this type of engine.

# THE AEROPLANE AND ITS DEVELOPMENT IN ENGLAND UP TO 1914

# CHAPTER II

## THE AEROPLANE AND ITS DEVELOPMENT IN ENGLAND UP TO 1914

AMERICA, then, invented the aeroplane. France developed it, and demonstrated the vast possibilities of the discovery. And England—what of England? Well, like most other countries, great and would-be great, England first of all said the aeroplane was a fool thing and complacently adopted an official attitude which was, in effect, that fools who were determined to break their necks might just as well break them in aeroplane experiments as in any other way, providing only that they paid their own expenses. "Of course," said the bigwigs in Parliament, who drew big salaries for knowing things, but who preferred to interpret the terms of their agreements as "drawing our salaries for keeping the common people from knowing things,"—"Of course," they said, "we are watching developments. You wouldn't have us spend public money on experiments, would you? My dear sir! the people would never stand for it. The Government is losing enough elections as it is! No, we'll let the other nations do the costly experimenting, and then, my dear sir, why, we'll just come in and start building the very, very latest machines in any number—just as we did with motor-cars, you know. It's so exceedingly simple. Those annoying men who get up in the House of Commons and the House of Lords—they're not politicians. Lord Montagu is always warning us about the danger of the aerial invasion, but then, you see, Lord Montagu doesn't have to think about his constituents—votes don't interest him."

So there was no official encouragement of the aeroplane in England for years after the success of the invention and its infinite possibilities had been proved beyond all doubt. A few civilians went over to France and learned to fly at their own cost. Some brought machines over to England and did their best to inform the public of what was going on abroad. One or two officers in the Army and the Navy followed the example and, obtaining leave specially for the purpose if they were in favour with the authorities, but more often than not giving up their already hard-earned holiday, went over to the French flying school and entered their names as intending pilots.

For years practically every record in aviation was French out and out. Take the duration record in 1906, when M. Santos-Dumont flew for 21 seconds on November 12th. Dumont, of course, is a Brazilian, yet, so far as his flying experience goes, he is French enough for all practical purposes. The duration record stayed in France for nearly two years—on September 6th, 1908, it was held by M. Delagrange with 29 mins. 35 secs.; and then Wilbur Wright took the honour with a flight of 1 hour 31 mins. 21 secs. Less than a year afterwards the lead again passed to France—Paulhan, flying a Voisin machine, who put up 2 hours 43 mins. 24 secs., on August 27th, 1909. Germany had to wait five years to get the duration record, and then it went to her for a flight of just over 14 hours, on February 4th, 1914. So with the speed record, which stayed in the hands of Frenchmen and Americans—meaning the Wright brothers, mostly—until 1914, when a Mercedes engine broke all records for Germany. In fact, precious few records went to Germany at all until 1914. The reasons were simple enough; they will be discussed later.

As for the British aviation records, these were almost without exception by Continental aeroplanes and engines piloted by Britishers. It was France and America almost all of the time. France kept the game mostly in her own hands, but, every now and again, when so much money had been spent in experiments that the banks were asking about paying off the overdrafts, she sent an odd machine or so over to the United States accompanied by French or English pilots for the purposes of (*a*) showing the natives that all the wings in the world didn't belong to the eagles on the currency notes, and (*b*) that money flies! Lots of it flew back to France after the early exhibition flights.

After the first sensation of the aeroplane as an actual achievement had passed, most people gave it only casual attention, and outside money for experiment and development became almost impossible to obtain. Enthusiasts, however, spent their private fortunes, and up-to-date townships, anxious for publicity, organised "Flying Weeks." On the Continent International Cross Country races had a vogue, and visits to England were occasionally included. These races and competitions gave Britishers some idea of how the aeroplane was developing.

It was due, however, to the foresight and enterprise of one man, who fully appreciated the trend of events, that an effort was made to arouse the British national conscience. The same man, as much as anyone else, had given early encouragement and financial aid to the motor-car pioneers, and so was instrumental in laying the foundations of one of the biggest British industries. It will be left for future generations to pay what homage is due to Lord Northcliffe, whose newspaper, the *Daily Mail,* set out to warn Great Britain and the world in general of the danger that was threatening, and, by offering princely monetary prizes amounting to many thousands of pounds, endeavoured to create a British aircraft industry capable of meeting the aerial needs of the country both in peace and war. There was the prize of £1,000 offered for the first flight across the English Channel, in which there were no restrictions as to nationality of either machine or pilot. Following this was the £10,000 prize for the first flight between London and Manchester, and the further prize for an aeroplane race round Britain. Neither an English pilot nor an English machine succeeded in winning one of these. When the war broke out the seaplane race round Great Britain, organised by the *Daily Mail,* in which the main stipulation was that the flight should be completed within a period of 72 hours, was interrupted. The prize in this case was £5,000.

Private enterprise in England, although not possessed of adequate funds, was not neglecting any opportunity, and during the years 1909-14 British designs were equal, and superior to, the Continental attempts. In 1910, for example, Mr. A. V. Roe, who is now one of the most successful builders of aircraft in the world, produced a biplane which had both engine and propeller located in front of the wings, a design which has directly influenced aeroplane construction ever since. Many of the same builder's ideas in regard to triplane construction are embodied in the ultra-modern machines, although, at that early period, the type was dropped for reasons which had nothing to do with the excellence or otherwise of the aeroplane itself. In 1914 a second British constructor, Mr. T. Sopwith, built a seaplane for the Schneider Cup competition, contested at Monaço, which proved far and away superior to all competing machines. In March, 1914, the Aero and Marine Exhibition was held in London, and a Sopwith seaplane, under its older name of "batboat," was exhibited. What's in a name, however? To the German Admiralty nothing—for it bought the machine at a figure which was said to be the highest ever paid for an aeroplane. At the same time the "Wight" seaplane was purchased. This machine was also outstandingly good and superior to anything owned by the British Admiralty. This was in March. Germany declared war in August!

The continued successes of the aeroplane in the period 1909-12 forced even the British Government to admit that something ought to be done about it. Questions were being asked in Parliament, reports of progress abroad were being given space in the newspapers, and there were people, not without influence, both in and outside Parliament and the Services, who foresaw the future clearly enough, and who never tired of warning the nation of aircraft's growing power. But to persuade a usurer to forego interest on loans advanced without security is a childishly simple business compared with asking a popularity-hunting Government in any country to allocate money for the national defence in Peace-time. The Press raised a sum of money for the purpose of buying for Great Britain an airship of French construction. The ship was bought, the voyage across the Channel successfully undertaken and—nothing very much further happened—only that the ship was wrecked. Private interests also offered large money prizes for aeroplanes winning races and competitions.

Thus forced by pressure of public opinion, the Government began to buy, slowly, cautiously and not over-wisely, aeroplanes of both French and British construction.

The Royal Aircraft Factory was re-organised —in its very early days it was the Balloon Factory, and was supposed to be interested in building airships for the Army—alleged airships unkind critics called them!—and was supposed to include or comprise an experimental department for testing and experimental work. The idea was good, but soon the R.A.F. got it into its head that it was a born designer of new machines. It was. But some of its aeroplanes refused to fly at all, and others gave anything up to a 50 per cent. worse performance than those designed by private constructors. In place, therefore, of devoting itself to experimental work, the official factory set up as a builder of aeroplanes. The fact was repeatedly, and quite unnecessarily, denied, for there was one school of thought which maintained that national aircraft needs could best be supplied by outside contractors, while there were also those who argued that the Government could build its own machines in its own shops just as it built some of its own battleships. There was something to be said for both sides, and, if wrong there was, it was in the evasive and deceitful attitude officially adopted. The factory was supposed to be the servant of the Flying Corps, but it made itself master. The army pilots knew quite well what was wanted in the way of machines, but the Factory could admit no virtue in any unofficial design. It laid down scores of machines all of which, when awkward questions were asked in Parliament, were said to be purely experimental. What would happen to any private builder who laid down a score of machines simply for experimental purposes may best be left to the reader's own intelligence. Briefly, hundreds of thousands of pounds were frittered away, and although some good designs were occasionally evolved, their cost, including previous experimental work, was enormous. Easy proof lies in the fact that privately-owned concerns have not spent one-twentieth the money on experimental work and yet have produced far better machines. An official report not favourable to the Factory was issued by a Commission appointed to inquire into its working so late as 1916.

The time was, of course, much too early to achieve any high degree of type standardisation so far as the complete machine went, for improvements were of weekly occurrence, and radical changes, always a possibility, might have involved scrapping on a huge scale; but there was no good reason why standardisation within types could not have been attempted. Skilled men were retained on the pay-roll of the Royal Aircraft Factory who made such things as turnbuckles, which could have been bought, as standardised products, from numbers of firms at less than one-quarter the cost of production in the official works.

In deference to those critics, an ever-growing number, who thought that private constructors should be encouraged in order that their works' organisations should not be lost to the country, which, in case of need, would want them very badly indeed—the time came sooner than most people anticipated!—outside firms were asked to tender for the building of the machines to official designs. Under this scheme most of the orders placed went to firms who were quite independent financially of any official assistance.

But there is this to be said for the British authorities: they, in common with all other nations, were suddenly asked to accept a comparatively new and startling invention which, should the claims made for it prove true, would revolutionise all existing ideas of defensive and offensive warfare. For years the national policy had been considered, checked and elaborated by the most competent professional fighters and strategists. These fighters, who had made a life-study of the handling of men in the field, of artillery, of cavalry, and of sea power, were suddenly asked to revise all their life-long theories and to help by every means at their disposal the progress of a new weapon which, should the claims made for it prove true, would render much of their own knowledge and training obsolete, and call for the substitution of a tried for an untried

SPECIMENS OF AIRCRAFT IN THE BRITISH MILITARY TRIALS OF 1914

In the centre the late Colonel Cody's huge machine, which won first prize of £5,000.
Above, the Deperdussin Monoplane; below, a Hanriot Monoplane,
and in the distance one of the B.E.2 Biplanes.

A SIMPLE STUNT!

By 1916 every military pilot had, perforce, to be a master of "stunt" flying. The illustration shows a machine in a "tail-slide," a breathless and spectacular trick which is, as a matter of fact, one of the easiest and safest tricks in the airman's repertoire.

scheme of defence. It was asking too much of human nature, and, to those who urge that the country and its needs stand first always, it may be pointed out that successful strategy prefers certainties to risks, that active service generals are not supposed to be either dreamers or inventors but soldiers, trained in the use of such weapons as *the country, not themselves,* can provide, and that, whatever be the faults or virtues of the Britisher, nobody would accuse us of originality in thought or mental quickness. It would be obviously unjust to blame a general who, told in 1912 that the greatest war in the world's history would break out barely a year later, and that, in four or five further years, that war would be lost or won in the air, regarded the speaker as a mistaken enthusiast at best and a fool at worst.

In 1912 the British War Office organised a series of aeroplane trials in which the late S. F. Cody, flying a biplane of his own design and construction, carried off the first and most important prize of £5,000. The Royal Aircraft Factory also produced a biplane which was admittedly superior to any of the privately-designed competing machines. In 1914 the authorities, impressed by the fact that they were practically dependent on Continental makers for aeroplane engines, organised a Naval and Military Engine competition, in which, to this day, reference has to be made to unofficial records for accurate particulars of the units entered, the officials, apparently, being unable to distinguish between air and water-cooled engines. A unit described by its makers as of 90-120 h.p. was, in the official *communiqué* issued to the Press, split up into two engines, one of 90 h.p. and the other of 120 h.p. A first prize of £5,-000 was offered and was won by a firm whose units had already done exceedingly well in various record-breaking flights, but the authorities had not previously seen their way to offer this or any other British maker suitable encouragement prior to the competition. The monetary inducement did real good in persuading some of the big engineering firms already possessed of every manufacturing facility, and with extended experience of internal-combustion engines, to turn their attention to the building of aero motors. Every well-informed aviator already knew that some of the British engines were in no way inferior to the best of the Continental products, but evidently the authorities did not believe it. For want of official encouragement their builders, prior to 1914, might just as well have turned their attention to other work. The war broke out before the results of the competition were published, and so the country had no opportunity of seeing what the authorities were prepared to do for the native industry when its merits had been conclusively proved.

*But England was beginning to wake up.* A number of private concerns, the majority having been handicapped by lack of funds for years, were just getting on their feet by the year 1914, and at the International Aero Exhibition held at Olympia previous to the outbreak of war British aeroplanes and engines showed up well in comparison with the best efforts of their competitors. Foreign Governments were buying the latest designs of British makers, and these, the financial pressure eased somewhat, were the better able to experiment and carry out their ideas, with the result that British machines were securing quite a number of prizes, both in Great Britain and abroad. A number of flying grounds and schools came into being for the training of pilots, and the public began to take a more intelligent interest in the progress of aviation.

Early in 1914 the British War office published its requirements from privately-designed aeroplanes before their purchase by the authorities could be considered. It is interesting now to look backwards and see what was expected by the military rather less than four years ago.

A light scout, carrying pilot only, had to carry petrol for a flight of 300 miles, have a speed range of between 50 and 85 miles an hour, climb 3,500 feet in five minutes, and have an engine which could be started by the pilot unaided. A light-type reconnaissance machine had to have a tankage sufficient for 300 miles of flying, carry pilot and observer together with an 80 lb. wireless set, have a speed of between 45 and 75 miles per hour, and climb 3,500 feet in seven minutes. A heavier biplane of the same type had a smaller fuel capacity and a lower speed range. A fighting aeroplane was required to carry petrol sufficient for 200 miles, together with pilot, observer and gunner, plus 300 lbs. for gun and ammunition. The speed range was to be between 45 and 65 miles per hour, 3,500 feet was to be reached in ten minutes, and there was to be a clear field of fire in every direction up to 30 degrees from the line of flight. This was the sort of machines the War Office wanted. Sometimes, when the aeroplanes were new and nicely tuned up, it got them. Afterwards?—well, that was an entirely different matter. Had the first machines which went over to France all been up to these standards their pilots would have been happier men . . . and possibly some of them would have lived longer.

In 1917 the machines could climb 12,000 feet in ten minutes, 22,000 feet in 22 minutes, and travel at 130 miles an hour at 15,000 feet.

What was the position of Great Britain immediately before the war so far as her aircraft went? The Royal Flying Corps was created in 1912. It incorporated the Naval Wing, although this latter was managed from the Air Department at the Admiralty. The Royal Naval Air Service was not created as an independent arm until July, 1914. The R.F.C. was divided into eight squadrons with reserves which, in reality, were non-existent. The squadrons were located in widely-separated parts of the country; they held no communication each with the other; and their efforts were not, in consequence, co-ordinated. The Army Manœuvres of 1914 called for a concentration of the squadrons with a view both to the pilots gaining actual experience of working with troops in the field and as a means of giving the troops themselves an idea of what aeroplane work could do for an army. The German and Austrian Army Staffs took advantage of the concentration to visit Salisbury Plain, where the machines were housed, and, being afforded every facility to make a thorough inspection of British aerial preparedness, or lack of it, by the obliging British authorities, were evidently enabled to advise Berlin to " let the war begin."

In 1913 considerable criticism was levelled against the Secretary of State for War about the state of the Royal Flying Corps. It was alleged that the strength of the arm was dangerously low; that many machines were out of action, either through accident, prolonged usage, or lack of spares; that others were of unsuitable design and dangerous to fly; that no provision had been made for the supply of spare parts; that many army officers who were, on paper, shown as active pilots, were otherwise employed. On the whole the criticism was well founded, despite repeated official denials. The Secretary of State for War claimed that the R.F.C. had 120 efficient aeroplanes; but a month later it was shown that of these only 43 were actually fit for service. A month or two earlier, May of 1913, King George inspected at Farnborough all the aeroplanes of the British Army then available at the moment for active service. They numbered 17!

Considerable progress was made during the next year, but when the country declared war against Germany the Royal Flying Corps could only muster something like 80 machines fit to take the air. Nor, of these, was each and every one fit for active service judged even by the standards of 1914; all of them, however, could fly, and of many that is about all that can truth-fully be said. Not a single machine was fitted with a British-built engine. There were 80 h.p. Gnôme engines, 70 h.p. Renaults, and one or two Antoinette motors—but not one British. Although this was bad enough, the Royal Naval Air Service was in even worse plight and because the British Navy was the only sure thing between Germany and World Dominion, because it was the weapon that was to gain breathing space for the Allies, matters were not improved by its aerial unpreparedness. The month before war broke out the R.N.A.S. had about 20 machines, most of them land-going aeroplanes with the landing wheels removed and floats fitted in their place. The Fleet had been mobilised in July, 1914, and the King had arranged to review the ships and the seaplanes which, it should be remembered, belonged to a new arm only a week or two old. Affairs of State prevented the Royal visit, but the ships and aircraft carried out the arranged programme. The result was that most of the seaplanes and aeroplanes went into dock after a few hours of flying to effect necessary repairs.

What of the British airships? The Royal Flying Corps had one or two small and very inefficient craft judged in the light of later knowledge about what enemy countries had then achieved in airship construction, which, some time before the outbreak of war, had been handed over to the Admiralty. That department had itself previously achieved a certain amount of aeronautical notoriety by having had built a rigid airship, modelled after the Continental practice, which, on launching, broke its back! It was called the "Mayfly," and it will probably go down to fame as one of the most expensive jokes ever perpetrated.

*Then the war came . . .*

# DEVELOPMENT ON THE CONTINENT BEFORE 1914

# CHAPTER III

## DEVELOPMENT ON THE CONTINENT BEFORE 1914

UP to 1912 there was no doubt at all about the decisive lead France had secured in the development of the aeroplane. A favourite topic in military circles was the influence of the aeroplane on warfare, and while some maintained that aircraft would make war impossible either because, developed to its logical conclusion, it would make it too terrible for civilised nations to contemplate, others argued that strategy, when every move made by a commander could at once be made known to his opponent, would become impossible. France, however, was taking no chances, for she had lived too long next door to Germany voluntarily to run any risks. The development of the aeroplane on the Continent is a topic full of interest.

The Wright brothers used a biplane, and Henry Farman also favoured this type of machine, while Blériot achieved his successes with a monoplane. Various types of automatically stable aeroplanes made their appearance; some, if not exactly so successful as their builders could have wished, provided a vast amount of data which was invaluable to later designers who, as a matter of fact, eventually achieved stability by following known laws and with little radical departure, so far as general appearance went, from the machines successfully flown by the early experimentalists. As experience was gained, designers became able to guarantee results from the drawing board. Sometimes an apparent improvement in one direction brought about serious disadvantages in others. The machines became "tractors" or "pushers" according to whether they had a screw located before the main planes, or a propeller behind them. Biplanes and monoplanes, pushers and tractors, these became the most popular types of aeroplane. Each had and has its peculiar advantages. The pusher type gives the observer a clear view in almost every direction, and, if the pilot be located well forward, he, also, is more comfortable with the engine and propeller behind him. Against this must be set the danger of the engine's breaking from its housing in case of a crash and crushing the pilot to death when, otherwise, he might escape lightly. Enclosed and streamlined bodies received attention, and builders began to produce more compact machines. Collapsible and folding wings were a favourite study, and various types of drive between motor and propeller were tried in attempts to combine the advantages of pusher and tractor machines. The engine, for example, would be mounted in front of the wings, and the drive transmitted through shafts and chains to the propeller located behind the main planes. Elevators, tails, fuselages, landing chassis and each and every part were the subjects of continued experiment. Many kinds of wings, propellers, fins and air brakes were tried, and the scientific design and construction of propellers was made a specialised job after the first year or so of actual flying experience.

Materials provided their own little problems from the beginning. Wood was used in the earlier machines practically throughout. It was comparatively cheap, it was easily worked with the existing machinery, it was elastic as a whole and withstood considerable shocks without breaking, and, further, fractures were localised. When a wing, for example, was smashed, many of the wooden ribs survived and could again be used. Aviators with an engineering training soon turned their attention to the use of metal in aeroplanes, and as the supplies of suitable woods became limited—a stage that was early reached in France—this type of construction received more and more attention. All-metal machines made their appearance at an early date.

Metals, of course, can be made stronger weight for weight than wood, and climatic conditions affect them less; but metal working is an expensive job, and in aeroplanes their use is attended with several disadvantages. Joints, to take one instance, must be welded, and a welded joint is always a source of weakness. Nor can metal repairs be so easily carried out, while it is impossible to say how far weakness extends in case of local fracture. A mishap in landing when a metal wing is used means, as often as not, that an entirely new wing will be needed; but when the wing frame is of wood possibly 90 per cent. of the parts can be used again. The alternative to welding is to bolt the parts together, an expensive and complicated business which, if the joints be not designed by a well-trained engineer, is apt to be dangerous, and although the respective parts can be standardised, fractures are not so localised as with the more elastic wood.

Wing coverings were the subject of endless experiment before satisfaction was given. The making and application of the waterproof varnish known as " dope " is highly specialised work. The wings of the early machines were covered with unproofed cotton, which soon sagged—became "soggy" as the pilots have it—and was neither water, oil, petrol nor air-proof. The cotton later was rubberised as a defence against water and air pressure, and although this improvement helped, the oil thrown off from the engine caused decomposition of the fabric. Various paints and varnishes were next tried; shellac tightened the fabric, then slackened it, and later caused brittleness, and white lead paints were too heavy. The first really satisfactory dope had for its base a substance known as acetyl cellulose, which, properly applied to suitable fabrics, gives weather, oil and spirit proofness, together with a smooth finish which reduces skin friction to a minimum when the machine is in the air. Applied in suitable conditions the modern dopes have practically no ill effect on the health of the workers, being in this respect infinitely superior to some of the older dopes which were poisonous.

Engines improved step by step with the aeroplanes. The Wrights used an adapted car engine giving 12 h.p. in their first machine, but a year or so later two French makers were building a 35 h.p. four-cylindered water-cooled engine which was standardised by the brothers, and in which the most striking features were the simplicity, the obvious desire not to save weight at the cost of weakness, and the absence of a carburetter. Mr. A. V. Roe, now one of the foremost British builders, flew a tractor biplane in 1908, in which a 9 h.p. engine was used. In his little "Demoiselle" M. Santos-Dumont used a two-cylindered, water-cooled engine of the opposed type, developing 25 h.p., and M. Blériot, in his famous cross-Channel monoplane, used a semi-radial, three-cylindered, air-cooled motor rated as about 25 h.p. The call for more power was insistent, and in 1909 the most striking departure in engine design was first made public at the Reims Meeting, when the Gnôme rotary engine made its appearance.

Power and lightness governs the outlook of the aero engine designer, and in the Gnôme weight was saved by gearing the whole of the connecting rods to one crank-pin on a crank-shaft which remained stationary, the cylinders, arranged radially or star fashion round the crank-case, themselves revolving, together with the case, to which the propeller was bolted. In the important matters of weight, vibration, balance, and mechanical simplicity giving trustworthiness in use, the Gnôme radial engines marked a tremendous advance on all other types of engine. The first units distinguished themselves in several ways. Numbers of machines which it had been impossible to persuade off the ground took the air with their help, and other aeroplanes which had successfully flown with other engines became record-breakers when Gnômes were fitted. Despite mechanical deficiencies, which ought, by all the rules, to have made these engines extremely poor performers, their running power was affected little if at all; the waste of lubricating oil—the best castor oil was the favourite lubricant!—was tremendous. Out of every 100 gallons supplied about 35 were usefully employed in engine lubrication, the remainder being blown out of the exhaust valve. Cooling was a simple matter, for the cylinders whirling through the air at a speed of 1,000 revolutions per minute did all that was necessary. But because only one side of the cylinders were presented to the cooling air currents, distortion followed, and special piston rings to ensure gas-tightness were needed. Fuel was fed to the cylinders through the hollowed crankshaft, each piston drawing its cylinder supply from the crankchamber through an automatic inlet valve located in the piston head. Some very interesting problems in design were ingeniously solved in the early Gnôme engines. In the later units by this maker some of the early disadvantages and weaknesses have been overcome so that, for certain types of aeroplane, the rotary air-cooled engines are still preferred despite the enormous improvements made in the water-cooled stationary engines.

An engine similar in many outward respects to the Gnôme was the Esnault-Pelterie, which, however, had fixed cylinders. The type, however, had definite limitations and as improvements in other engines were made and the advantages conferred by the " R.E.P." were obtained in other ways, its manufacture was eventually abandoned.

Naturally, many freak engines made their appearance, together with others which employed some ingenious system but which for some reason or other could not be developed, although they may yet be. There were two-cycle rotary engines, and eight-cylindered units which had the cylinders in groups of two, fitted radially and at an angle of 90 degrees to the crank-shaft, the maker's aim being to secure long working stroke with low piston speed. There were to be had in the year 1910, vertical, semi-radial, V's, opposed and two-cycle type engines, ranging in rated horse-powers between 12 and 200, and costing from £75 to £960. Fifty makers were represented and these, between them, built about 90 different types of engine; the weights per horse-power, ranged as low as from 1.48 to as much as 10, and the number of cylinders varied between 2 and 14. Many of the units advertised at that time, it is to be feared, made their only bow to the public on paper, yet, leaving these out, the aeroplane constructor had a good range to choose from within a very few years of the first mechanical flight having taken place in Europe.

The majority of the engine builders were French and, of course, there were more builders of successful aeroplanes in France during the period 1909-12 than in any other country. Our great Ally, however, made the mistake of rushing development, and although she soon had big numbers of machines, they were of such diversified types that, for war purposes, many were of no value. There were the usual somewhat undignified quarrels between the constructors and the Government, spiced, also, with a dash of that irregularity without which the Frenchman, it seems, would find life much too dull and solemn a business to be endured. In the ordinary way no great harm would have been done either by mistaken French enthusiasm or stodgy, slow-witted British intellect, providing only that Franco-British quarrels and love-making were purely family concerns. The two nations have quarrelled and made friends for centuries; French wit has sharpened itself at British expense, and British commercialism has retaliated in pompous gibes about frog-eating for more years than most of our history memories will carry us.

Unfortunately, France and Great Britain and every other civilised nation had Germany, with her dreams of world conquest and her ape-like cunning and morals, to deal with. Count Zeppelin had built numbers of his airships, which had practically no commercial value and were expensive to build. At length, when the Count accomplished flights which were in effect military tests, the value of the huge airship as a war weapon forced itself on the German view, and, possibly because Germany had no idea of war and was a peaceful race, only desirous of living in peace with her neighbours (?), a huge national fund was raised following a mishap to one of Zeppelin's efforts, and in less than three months a sum of £300,000 was placed at Count Zeppelin's disposal. Enormous sums for airship and aerodrome constructions were additionally granted by the Government, and the Kaiser gave the old man his blessing—for what it was worth. "*Der Tag*" was drawing steadily nearer by this time.

Germany's efforts, although conducted in semi-secrecy, did not pass entirely unnoticed in other countries, but France, who had tried many airships, and who, in fact, supplied the original idea of the rigid ship, was developing the aeroplane, and Great Britain, indeterminate as always and having the Navy to fall back on, quite overlooked the fact that naval power would be of little use against air attack, and so did nothing, or what amounted to nothing. Again and again such authorities as Lord Montagu, who had absolutely no axe to grind, warned the Parliament and the nation of the coming danger. Figures of the performances and powers of the German airships were given, and it was pointed out how easily the towns of Great Britain, including London, would be at the mercy of the attacking airship in case of war. These were not imaginative efforts but were based on hard facts. Because Great Britain made not the very slightest serious attempt to meet possible danger of this kind, it can only be assumed that the country had no belief in the possibility of war.

It was not in the actual number of airships in her possession on the outbreak of war that Germany was so well placed. Rather it was in the long experience her engineers and builders had. The navigation of a big airship, for example, calls for a highly-skilled crew, and several German ships were lost in the early days simply because the crews were not sufficiently skilled in their handling. Again, the training of an airship crew is a lengthy matter. It is obvious, also, that workshops and plant for the building of monster airships cannot be called into existence in the course of a few weeks, especially when the work is being done by people with no previous experience.

A striking illustration can easily be supplied. Suppose the U.S.A. had built no ocean-going steamships of any kind, had no docks of any description, and owned factories accustomed solely to building such things as mill engines, sewing machines, mining machinery, and so on. Supposing, further, that a 5,000-ton triple-expansion-engined steamer were sent over to New York, and the U.S.A. were asked to build, say, one dozen similar vessels in the space of six months and, having built them, to supply crews capable of navigating the ships in safety to any port in the world, from men who never in their lives had been to sea. The task would be frankly impossible. But both France and Great Britain were presented with a very similar problem when war broke out, and although some number of the latest type German airships came into the hands of the Allies practically undamaged, and closely-guarded German secrets were secrets no longer, and although the ships were repaired and even re-built and were put in commission against Germany, that nation still retained a most decided airship superiority even in the fourth year of war. That a successful defensive was evolved affects the question very little.

In aero engine construction German manufacturers and engineers had such long experience owing to the work they had done for the airships that when the progress of the aeroplane could no longer be safely ignored, and it was decided to build a war fleet of heavier-than-air machines, Germany started in many respects on at least equal terms with France and Britain. In other respects she was even superior. For example, she was at once able to build water-cooled engines equal to any others so far as power and weight went, while in mechanical trustworthiness there was no doubt about the German superiority. The factories, such as those building the Mercedes, Benz and Maybach engines, were standardising their products and outputs when the French and British works were still experimenting, and when the rotary air-cooled engine made its appearance and proved its worth, arrangements were soon made for its manufacture in Germany. As a matter of fact, selling agents were first appointed, and then the engines were built under licence; but who will dispute that Germany would have stolen the engine had any obstacle been placed in her way?

As to the value of the experience gained in building airship engines, one example will suffice. When an aeroplane engine was needed in quantity the big makers received hints which were more in the nature of commands than anything else. The Benz people had no need to experiment; when the drawings of the first engine were completed, the works instructions were for its production in batches, and the first unit to leave the works carried off as a beginning the special prize of 50,000 marks offered by the Kaiser! As another count in the indictment against Germany of having prepared for and forced the war stands the fact that, after putting up an excellent performance, the whole output of the Benz factory was commandeered for war aeroplanes in 1913. And again. For some years the German motor-car manufacturers had held out of the world's famous races. As *The Day* approached, and final details were being overhauled and tested, it became necessary as a last precaution to put the German war engines against the best and most powerful products of future victims. So the German factories again took the road with their cars and engines. The Mercedes team entered for the Grand Prix, the world's premier car race, in 1914, had engines guarded from curious eyes like State secrets, as, indeed, they were. The race was won. The engines demonstrated their marked superiority. Germany's leaders were satisfied, for engine improvements are not made in a day, and this was to be a quick, smashing war, giving victory before the nations attacked could get breathing time. Since then numbers of enemy aircraft have fallen into Allied hands, all fitted with the 1914 Grand Prix type of car engine! There is no need for diplomatic subtlety in drawing up the indictment against Germany. Let the plain man judge, and let him base his judgment on simple facts which he can understand. Such facts as these we have cited.

And how did the German authorities encourage the native aeroplane industry when it was decided the machines must supplement the Zeppelin fleet? Let plain facts speak again. Take the prizes offered by the German National Aerial Committee for cross-country flights. The first was of £5,000, and was won by a flight of 1,290 miles; the second was of £3,000, won by a flight of 935 miles; and there were five further prizes ranging in value from £2,500 to £500, and, with one exception, every one of the winning machines used a 100 h.p. standardised Mercedes engine. These munificent awards were only part of a series, for time was the essence of the contract. What were a few hundred thousands of pounds when world conquest and dominion and thousands of millions of pounds in indemnities were the final aims?

Other countries offered monetary inducements but none made military requirements and tests so vitally important as Germany.

In the beginning of 1914 Germany had sixteen Zeppelin sheds, nine of these holding more than one airship. Her pilots were constantly practising night flights, and, although the figures are naturally not available, it would not be surprising to know that Germany spent as much money on the provision of *night landing stations alone* as England spent on aeronautics altogether in the years immediately preceding the war. During the first months of 1914 practically all the flight records, in speed, duration, passenger carrying, height and distance, were taken by German pilots. The Allies, however—good easy peoples—were hurt in their feelings, and taken by surprise, when Germany went to war, for, you see, they had received no warning!

# THE INFLUENCE OF WAR ON THE AEROPLANE

## CHAPTER IV

### THE INFLUENCE OF WAR ON THE AEROPLANE

THE aerial preparedness of the belligerent nations on the actual outbreak of war is a matter of outstanding interest. Great Britain's position has already been hinted at; she had precious few serviceable machines in the memorable August of 1914, but, by a tremendous effort eighty-two were scraped together and sent over to France. They were a strangely-mixed lot and included most of the types the British Army had been experimenting with for quite a long time. There were 80 h.p. Farman biplanes, and an assortment of Royal Aircraft products, Caudron and Short biplanes, and Blériot, Nieuport and Deperdussin monoplanes, together with several of what the Americans call "orphan" machines. An enthusiastic aircraft collector would give his ears for a representative collection of these aeroplanes, and he would make a bargain at the price.

Most of the machines, alas! went West in the very early days, but not before they had given invaluable service to the sorely-pressed Allied armies. A pilot of the British Royal Flying Corps took news to General Sir H. Smith-Dorrien, who had taken over part of the line with his advanced Division, that he was faced by three German Army Corps, with strong reserves, instead of the three German Divisions he had been given to understand were opposing him. When other scouting aeroplanes had confirmed this news, the disposition of the British Forces was changed, and the wonderful retreat from Mons, which is commonly said to have saved the whole of the Allied armies in France, was begun in time only because of the news brought by aeroplanes.

The spares needed for the mixed lot of British aircraft were enough to daunt the heart of the most hardened army storekeeper, but a lot of work in booking, indenting and checking was saved by the simple fact that none existed. The machines themselves were slow and outmatched by the German aircraft, but, fortunately, the enemy was engaged further south in his scheme of crushing the life out of France—a little job, by the way, he is just as far from finishing as he was in the beginning—and so the British aircraft managed, in some miraculous manner, to outlive the storm until reinforcements were sent.

France went into the war with between 500 and 600 fairly serviceable machines in which the chief defect was type diversity, calling for thousands of different spare parts, and leading to much confusion and delay in the factories, which, while they were engaged in keeping their own products in the air, could not get ahead with any systematised programme, and so production suffered. On the other hand, France had a well-trained and numerous *personnel* and a splendid auxiliary equipment. Little was heard of the doings of the air service in the first few months for the reason that the French Army is no publicity lover, and also because it was too busy fighting to bother about fine writings. The Germans tried to overwhelm the French from the beginning, but their machines were not numerous enough. The use of aircraft in war was not so well understood then as it is now, and the Germans thought that something like a 50 per cent. superiority in aircraft would turn the trick. They were wrong, as was quickly demonstrated. Completely to blind the French commanders while keeping themselves informed of every move and throwing big armies against the weakest places was the German plan. They needed a 300 or 400 per cent. superiority in aircraft to do it, and this they had not got; therefore the plan failed.

The mentalities of the two peoples also had much to do with the result. The German fought to numbers, orders and the military text-books; he ran no avoidable risks; and the individual pilots avoided battle whenever possible because their definite instructions were not to waste valuable machines and trained pilots. On the other side, the French airmen went about seeking whom they might devour. They raked and harassed and annoyed the enemy in the air and on the ground; they threw bombs at him—missing for the most part, but upsetting German nerves quite a lot, for the Hun likes every other nation to fight according to the text-book, while he himself thinks out new forms of frightfulness—and worried his aeroplanes with the quick-firing 75mm. guns, and took photographs of him, and shot his pilots in the air with rifles. Altogether the Germans had a very thin time, and although they had superiority in the air they had not supremacy, and so they could not keep news of their movements and concentrations from the French observers. When the Hun threatened any part of the line the French commanders were able to scurry up reinforcements in time to parry the threatened attack.

Germany had well over 600 aeroplanes, mostly two-seaters, when war was declared. These were standardised throughout, and the factories behind the line were turning out numbers of similar craft to make good losses and increase the German superiority. Each machine was fitted with bomb-dropping gear and cameras. The Hun also possessed a few fast single-seated scouts which could be used as occasion demanded. But where the German scored most was in his method, his training and his organisation.

The German commanders knew exactly what their aircraft could do from the day war was declared. For example, the aeroplanes were to go scouting, and, in addition to securing news of enemy movements, photographs had to be taken of field and permanent fortifications; this done, the aircraft had to "spot" for the guns, signalling, by means of coloured lights and evolutions in the air, the ranges and results of the firing. All detail had been previously arranged. This was where previous training was so valuable, and, unless the French or British aeroplanes took a hand in the game, as often enough they did, the plan worked well.

The German aerodromes were strategically well placed close to the frontiers so that full striking force could be brought to bear without delay, and the production of training machines went on automatically. From the first day of war the system was working behind the lines to supply both aeroplanes and pilots and observers. So well did it work, in fact, that the wonder about the whole thing is that the German scheme did not go through. Perhaps, on the whole, it was too perfect, too delicately balanced, and when opponents preferred to fight in their own instead of the German way, the cogs began to slip a little. The French, to give an instance of what happened, quickly saw where the German aircraft and system had the advantage, and set themselves to build machines superior to the enemy's. Because the French manufacturing organisation was fairly fluid and was backed by superior technical brains, the machines were produced, and the German factories were forced to halt a little in the set scheme in order to think out some effective reply. It meant disorganisation, a thing the methodical Hun loathes.

The German flying grounds were absolutely unique, and still are so far as available information goes. In any case, they were superior in 1914 to some of the Allied aerodromes three years later. Lighting systems had been so carefully studied, and the penetrating powers of various lights, colours and lenses considered that, before the war, night-flying and landing was a part of the German army pilot's regular instructional course. Towers and light-houses had been erected up and down the country, thick sheets of glass, illuminated from beneath, were set in the landing grounds, and the pilot was supplied with information as to the direction of the wind, his position above the aerodrome and other useful knowledge by means of painted rings, arrows and other warning signs shown on the glass and in the aerodrome. How the Germans must have laughed when, following the Zeppelin raids on Allied towns, many articles appeared to the effect that the aeroplane, the most effective reply to the airship, could not be used at night because it was purely a machine for use in the daylight. The Allies have gone a long way since then, and when the Zeppelin menace was finally overcome and the Germans began their raids by aeroplane, hundreds of machines went up to beat off the attack; the mishaps caused to the defending machines either by the ground defences or by landing in the dark were well under one per cent.

Twenty-one illuminated aircraft stations were admittedly in existence in Germany before the war. That at Bernkastel-Kues gave a flash of 250,000 candle-power, while the light near Dresden gave the same; the one near Neustadt in Hanover was one of 300,000 candle-power. The most powerful of the lot was at Weimar, and consisted of a revolving electric flash, located 15 metres above the aerodrome, which gave 27,200,000 candle-power! The Hun made practically all his aeroplane tests of a military nature from the beginning. He invited civilians to enter for the sake of appearances only. For example, there was a surprise test carried out in May of 1914, when 24 two-seated machines, belonging to the Army, started from widely-separated centres in Germany to fly to Doberitz, an average distance of 300 miles. All the machines arrived safely, and all returned without accident. Curiously enough, the majority of the reliability tests carried out by army pilots seemed to involve a great amount of Frontier flying.

The Zeppelins did not fly over France so frequently as they did over England for the simple reason that the French anti-aircraft gunnery was an unknown quantity, while the British powers in this direction were well known and the Germans were not impressed. But even at night time powerful airships cannot fly over any country without attracting some attention, and when the Zeppelins had been over Britain on half-a-dozen occasions the Northcliffe newspapers got a little tired of the thing and insisted that the Government should take notice of what was happening. Germany had good friends in England then as she has now. The Free Trading newspapers who seemed to make a specialty of the " Everything German is good enough for us" song, made great play of what they called the "scareships." Some of the editors had been over to Germany by express invitation and had been given dinners and decorations. The Kaiser used to lunch with Labour Leaders when it suited the German book to do so. Despite much German-inspired writing, however, the country was really aroused, and had some tangible and definite proof been forthcoming, Germany might have been in the war some months before the day she had arranged. The "scareship" newspapers gave the Hun an idea to throw England off the scent. Paul Brodtmann, the head of the Continental Tyre and Rubber Company in England, who was also a prominent man in the German spy organisation, started out to allay any suspicions that had been aroused. He obtained one or two small cigar-shaped airships and, after having fitted them up with a simple device which would, soon after they were released, ignite a ball of wool suspended below the ship, and draw the attention of people to the light in the sky, he sent them up. All but one were blown out to sea. The exception came to earth in Wales, was discovered, and, lo and behold! the great spying German airships were nothing more or less than a stupendous advertisement for a firm of tyre manufacturers. So said the "scareship" newspapers. The Continental Tyre and Rubber Company was, it should not be forgotten, the concern which tried to "corner" aeroplane fabric before the war, and only failed more by bad luck than bad management.

Belgium could put very few machines in the air, certainly not more than forty, and of these barely 50 per cent. could be termed fit for active service. The few machines which went up, however, did splendid work before the Hun put them out of action. Belgium had not considered it necessary to spend big money on aerial preparedness, although as early as 1890 a small Military Balloon School had been formed, and in the year before the war £20,000 had been granted for the purchase of aeroplanes, mostly French, and the general improvement of the service. The French have since supplied Belgian aviators with all their machines, with the exception of some seaplanes and a very few land-flying machines sent over from England.

Italy has been building first-class aero engines for many years, such firms as Fiat and S.C.A.T. being in no way behind any of the Allied countries in engine design. Many of the long-distance records and performances in 1917 were by Italian machines and pilots. The Fiat Company is one of the most important of its kind in the world, and employed in the fourth year of war approximately 25,000 people. In pre-war days numbers of French machines were bought by Italy, and for a time even the native-built products were copies of French designs. Later some very successful all-Italian machines were built, and the Services relied almost entirely on Italian constructions.

The Russian aircraft equipment was like most other things Russian. Enormous sums were spent to provide machines, and those which actually reached the scene of the fighting gave a good account of themselves. Hundreds of French aeroplanes, however, never got any nearer to the fighting than the docks and railway sidings. There they stayed with the motor equipment, ammunition, guns, clothing and other materials sent from France and England and the United States. Efforts were made to get Russian aircraft factories in operation during the war, and some progress was made, but, even at best, they were dependent on the Allies for magnetos and much other gear. The Russian declaration to the effect that the country was tired out and must have a rest while the Allies took the load off her shoulders was—well, words are hard to find. France, according to this,.only entered the war somewhere in 1917, and such little affairs as the Marne, the Aisne and Verdun were holiday jaunts more in the nature of picnics! Belgium, naturally, hardly knew there was a war on; and the first British Expeditionary Force, the best part of 200,000 strong, which died to stop the German drive for the Channel ports, were under the delusion that they were helping at some kind of fashionable garden party. Nor did the British Navy know about the war, presumably. But Russia picked her own course, and the time is too early for judgment to be passed. But it is hard not to reflect that the country has achieved something of a reputation for never having finished any war begun by herself!

The United States was in an entirely different position to Russia. Until the value of the aeroplane in peace and as an asset to humanity was proved, the U.S.A., straining every nerve to remain neutral and believing that the war in the air would be confined to Europe, made no attempt to provide an aerial fleet commensurate with its standing as a great Power. At the Peace Conference, when Germany urges, as she will, that the States was preparing to join the Allies for a long period before diplomatic relations were broken off, this point may well be remembered. Anyhow, whatever the reason, America had no airfleet. But, unlike Russia, the U.S.A. is a manufacturing and engineering country, and, when put to it, can possibly equal in output the rest of the Allies put together. The designing of the Liberty engine inside a month, the building of over 20,000 aeroplanes, the training of over 100,000 men to form the *personnel,* plus the provision of an enormous amount of auxiliary equipment, all this in a year, demonstrates what the country can do.

As for the other countries of the Alliance, they have relied for their aircraft on France in the beginning and, later, when the factories became organised, also on England. Intensity of air fighting was confined mostly to the Western Front, and a dozen machines operating in, say, Egypt had a life of months as compared with weeks in Europe. The race for overwhelming aerial supremacy from the beginning was between England and France against Germany, and for three years it was a neck-and-neck race. If the United States keeps its conduct of the war free from those paralysing political influences which have been so expensive to France and England, the race should soon be turned into a procession.

Germany put her standardised two-seated biplanes up against France in great numbers; their pilots and observers had received a more intensive and extensive military training than those of any other nation; they knew exactly what was expected of them, and the machines were better equipped in detail and accessories for the job. Germany lost the war, however, amongst other reasons, for the sake of an extra quarter of a million pounds, a minute fraction of the money she had spent in preparation. In other words, such a sum would have provided a thousand extra aeroplanes with which to begin, and had these been available they could have blinded the Allied commanders, the German hordes could have been thrown against the weakest links in the defensive chain, and there was nothing to stop a march straight through to smashing, unquestionable victory. The sentimentalist likes to talk about never accepting defeat, but of going on forever rather than acknowledge German mastery; but the defeated country does not, in strict fact, go on fighting—its conqueror does not let it!

As a class the Allied pilots were far more brilliant than their enemies, but, unfortunately, while one French machine was engaging a German unit, a second Boche, the odd number of German superiority, continued its work of observation or "spotting" practically without interruption. This, of course, was in the days when the "specialist" machine was unknown. The "general purpose" unit was exactly as implied by the name, and being looked on as an all-round machine it was thought that should any unexpected need arise it would be possible to detail some number of these standardised craft for the job. Some few leaders were convinced that the day would come when aeroplanes would be as many-typed as naval ships, and used in as many different ways for as many purposes. Lectures expressing views of this kind were given in the leading European countries before the war, and it was urged that aircraft could not be considered merely as a weapon for the uses of armies and navies in the same way as the artillery, but that it was an entirely new arm in itself. These views, however, did not find immediate favour with the responsible authorities, and it was only in the fourth year of war that the British War Office agreed to the establishment of an Air Council for the administration of the Air Force and the Defence of the Realm of Air, with a Secretary of State at its head, thus putting the air service on an equal footing with Foreign, Home, Colonial, Indian and War affairs.

The German machines were much better equipped than those of the Allies. All the early German 'planes had the swept-back, curved wings which gave the name to the type. At first the untechnical observers believed that the Taube machines were by some one particular maker, and it was not until some time later that the truth was generally known. The enemy authorities were quick learners, and the war had hardly begun before the obvious disadvantages of the Taube type were realised, but, as considerable numbers were on hand, they had to be used. Improved tractor biplanes were soon coming from the enemy shops in comparatively big numbers, and these were no more copied from Allied designs than the latter themselves were copied, the truth of the matter being that in the search for efficiency any competent designer will take advantage of improvements made in other directions . . . he would not be competent otherwise.

The great point about the first machines of the German Army was their complete equipment. They had a hand-operated magneto engine starter which was about 50 per cent. efficient, and which was, despite this little weakness, anything up to a hundred times more efficient than the Allied engine starters, which were, in fact, in existence, but not on the army aeroplanes! A small independent screw, mounted on one of the main planes, furnished power to the dynamo used for the wireless set, the transmitter being located in front of the observer. To make full use of these equipments Germany had, in addition to the wireless sets which travelled with the armies in the field, established a complete interlapping chain of wireless stations along her frontiers and coast-line. A map published in November, 1914, showed thirty-four, so that, although the wireless sets of the aircraft had a somewhat restricted range as compared with later appliances, there was little chance of enemy aircraft being attacked and overwhelmed before they could manage to get an "S.O.S." in somewhere. The radiators were of a sectional type to facilitate repair and to allow of maximum efficiency in engine operation whether in winter or summer. Cameras were common to practically every machine, and dual control was also fitted, so that in case of the pilot's being wounded the observer had a chance of landing safely. There were accurate compasses and pressure petrol gauges, height and speed recorders, bomb-dropping apparatus, and a whole range of other detail equipment and accessories. These "gadgets" were not perfect; they have been greatly improved since; but the point is that the German pilots had them for what they were worth and the Allied machines had them not.

What the Allied machines lacked in equipment their pilots made up in sheer impudence and daring. They were at a big disadvantage in any case and so, argued the airmen, they might just as well cause as much trouble as possible. They took up rifles and hand grenades and automatic pistols; they bought accessories and extra fittings, often enough at their own expense, from the private manufacturers, and they achieved what came to be called the "Christmas Tree" aeroplanes. Already at a disadvantage in speed and climbing powers, and harassed by the superiority of the enemy anti-aircraft guns, which made matters worse, the extra weight of the fittings slowed the machines and made every flight, especially over the lines, a sheer gamble with death. The German pilots did not like the individual air duels; it was not in the text-books; but the French and British "had to go through it" in any case, and they made a point of taking as many Boches with them as could possibly be managed. It was the period when, as Sir John French put it in a famous report: "Our airmen had established a personal ascendancy over the enemy."

Those at home who knew the truth choked back their curses and set to work to provide the finest pilots in the world with machines which should be worthy of their skill and bravery. But the inertia of the Government Departments acted like a blight, and although matters improved slowly the enemy was again and again able to put new machines in the air which, for a time, regained for him aerial superiority.

The French sent out some excellent machines in the early part of 1915. There were Blériots which gave an excellent chance for observing, photography, and fighting with pistol and rifle; big Caudrons, which were fine, steady and trustworthy machines for reconnaissance and bombing work; Farmans, incorporating the best ideas of the brothers, Henry and Maurice—Horace was the common name for the co-operative machines—which did splendid maid-of-all-work service; Morane-Saulnier monoplanes, called "parasols" because of the wing mounting and the location of the pilot, and which were speedy little machines; Nieuports, fast craft that the Hun pilot liked to avoid; little "Spads," single-seated machines and amongst the best of their class; and big, well-protected, bomb-dropping Voisin biplanes. All these machines did not materialise immediately, nor are the types roughly indicated all that the makers produced during the war. Other makers contributed their quota, and improvements and improvements were made of which it would be inadmissible to supply details in case the enemy has failed to secure sufficient data to aid him in reproducing the best features. In modern war, alas! aircraft secrets are soon common property, but as the thing cuts both ways, matters balance about equally.

The faster French machines soon began to make matters very uncomfortable for the "general purpose" German craft, and a reply became necessary. The Fokker monoplane was effective for a while. The very first Fokker was a "gas-pipe" machine, a name sufficiently explanatory, and was offered to several European Governments who, perhaps in the hope of saving the inventor's feelings, did not see their way to acquire any rights. The later Fokker to be used by the Germans was a compromise machine having a lot of the French "Morane" in its build. The engine was a German version of the Gnôme incorporating several improvements. A fixed machine-gun, firing through the propeller, was mounted and, because the machine was fast and a good climber, it played havoc with the slower Allied craft until a reply was evolved.

Synchronisation of machine-gun and engine had not then been perfected and the tips of the propellers were armoured with metal plates which deflected towards the ground those bullets which failed to clear the blades. The favourite Fokker game was to climb to a great height and to swoop unexpectedly on the slow, low-flying Allied aircraft. So serious were the Fokker raids and so deadly their attacks that their victims could only make any show of defence by going up in twos and threes, the duty of the odd machine being to look out for the death-dealing Fokker and to engage and detain it while the observation craft streaked for home. These tactics imposed a great strain on the Allied commanders, who were already handicapped by an insufficiency of aeroplanes. It was not until the British B.E.2C. aeroplanes arrived in France in any quantity that much progress could be made.

But the Fokker was not really a good machine; it was faster than any the Allies then possessed, that was all. Soon the reply came, the British found the de Haviland and some of the later Fighting Experimental (F.E.'s) machines, and the day of the Fokker of the early type was over. New biplanes of the same make made their appearance and were favourite machines with the crack German pilots; otherwise they were no better than several types flown by the Allies.

The Albatros biplanes were much used by the Central Powers for war purposes, and a number of improved designs was put out. Captain Baron von Richthofen's famous "travelling circus," manned entirely by selected star pilots, used this make of machine. At first this maker produced comparatively slow craft with ample and comfortable accommodation, to the military specification, but very trustworthy and of good weight-carrying powers. Later, however, some very fast small machines, very similar to an English design which was always about three months ahead of the Germans, made its appearance and did a lot of damage until better Allied machines came through in something like adequate quantity. The Aviatik biplanes did well, and the Halberstadt fighting scout, a fast, cleanly-designed machine, using a powerful engine, came into prominence during the third year. The L.V.G. machines (built by the Luft Verkehrs Gesellschaft) were hefty products distinguished more by their all-round usefulness than by any grace of line; a clever Swiss engineer was chiefly responsible for their production. These were some of the more widely used German aeroplanes. The big Gotha bombing machines were built after a big English machine had fallen into German hands, by the Gotha Waggonfabrik people, who had first of all produced seaplanes and, later, a small and fast single-seated scout which was a good specimen of its class.

So had the race been from the beginning. Superiority, not supremacy, has ebbed and flowed from one side to the other, and many excellent chances were lost on both sides. Jealousies, department muddling, poor official designs, ineffective production methods have all added to the tale of delay and loss. But in spite of all the aeroplane has steadily improved both in performance and trustworthiness until, when peace returns, the commercial chances of aircraft cannot possibly be overlooked by any Government which desires to play any part of importance in the world's history. Added to this, our knowledge of the air and its conditions have been greatly extended and thousands of skilled pilots have been produced.

To sum up the influence of war on the aeroplane, the Germans began the war with standardised aircraft more remarkable for their general all-round reliability and complete detailed equipment than for any power of manœuvre, speed or climb. The Allies began with numbers of machines, some fast, some slow, some poor, some good, but without any definite scheme either of working or production. After a while came a demand for improved weapons both for attack and defence. Next came a call for machines giving a better view for the observer and, afterwards, a call for designs which allowed of a bigger field of attack and which presented fewer vital spots to the attack of the enemy. Bomb-dropping apparatus had to be bettered, detailed equipment improved, accessories made more reliable, and all the time the pilots called for more and ever more powerful engines, speed always, greater ease in manœuvring and climbing. The German raids against the Allied towns led designers to produce heavy weight carriers of moderately high speed and climb and of great flight range.

The requirements of the military authorities prior to the war have already been given: three years later machines having a speed in excess of 150 miles an hour had been produced, and as to height, reports were common during the battles of 1917 of machines engaging enemy aircraft at a height of between 17,000 and 22,000 feet!

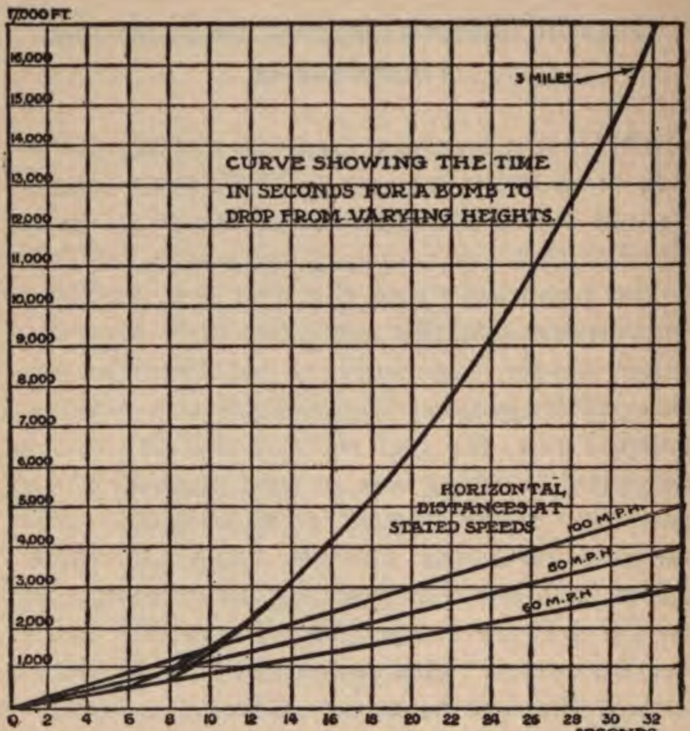
# BOMBING, RECONNAISSANCE, SPOTTING AND PHOTOGRAPHY

# CHAPTER V

## BOMBING, RECONNAISSANCE, SPOTTING AND PHOTOGRAPHY

THE first bombing from the air was primitive in the extreme. The German specifications called for their Army machines to be fitted with bomb-dropping apparatus, and it is to be presumed from this fact that the Hun knew more about this particular work than most other people, especially as the Zeppelin developed its greatest frightfulness as a bomber. Despite this, the fact remains that the enemy aeroplane bombing was, in the beginning of the war, just about as poor as that of any other nation. Even the aircraft enthusiasts themselves believed that bombing from aeroplanes would only be a side issue at least for many years to come. One prominent British officer was of the opinion so late as June, 1914, that aeroplanes could do considerable damage to aircraft on the ground by sweeping down suddenly and launching bombs from a low altitude, advantage being taken of the ground contours, but he believed that attacking troops from above was still very far in the future, as the amount of damage done would not balance the risk of the loss of the aeroplane.

Bomb-dropping was not given very serious




attention by military authorities before the war. Sometimes Service pilots were allowed, as a sort of treat for being good boys, to make a few tentative experiments, and at those aerodromes which depended on the shillings of the public, to some extent orange-dropping "stunts" were occasionally a feature of a flying day. Under very favourable conditions the pilots registered a fair number of hits, but dropping oranges on marked circles in a friendly aerodrome and placing bombs on an enemy shipyard are two vastly different matters. Anti-aircraft guns ranging at 15,000 feet, together with the presence of enemy aircraft, give the attacking pilot little time to manœuvre for position or to glide down to 1,000 feet in order to make the aim fairly certain.

The French and British pilots did some very daring bomb-dropping in the first year of the war. Arrived over their objectives they dived to heights counted by a few hundreds of feet with the engine full on, reaching almost incredible speeds as speeds were then regarded, and released their bombs at what they thought the crucial moment before making the best of their way out of the danger zone. Some results were, of course, achieved—for example, there is good reason to believe that Germany lost some few airships and sheds through Allied bombing attacks soon after the war began—but in the whirl and excitement of the moment it was almost impossible for the pilots to see what actual damage had been done. Probably a lot of the noise they heard was the sound of their own engines and the bursting of shells in their near vicinity, while the smoke and dust on the ground gave the impression that great damage had been done. Bombs missing their objectives by a few feet often enough do very little damage, and there are only enough exceptions to prove the rule.

A bomb dropped from the air leaves the machine at a velocity equal to the flying speed of the aeroplane at the moment the bomb is released, and, in practice, it has been found that with a speed of 100 miles an hour, a bomb, dropped at 10,000 feet, reaches the ground about 12,000 feet in front of the point over which it was dropped. This information may be of value to New Yorkers who are apprehensive—very rightly so in the opinion of many competent judges—of a German air raid against the city.

Many things had to be considered by the bombing pilot, who needed to be something of a lightning calculator and first-class mathematician. The height, speed and angle of the aeroplane, the direction and velocity of the wind, and the weight, shape and size of the bomb itself all have to be taken into account. The first bombs to be used in warfare were very primitive arrangements, and were almost as dangerous to the machines carrying them as to the enemy. It was impossible to secure a safe landing with them on board, and no pilot, until very great improvements in various directions had been made, ever tried to effect a landing until all the bombs had been discharged irrespective of whether they fell on friendly or enemy territory. The shape of the first bombs compelled an over-and-over movement so soon as they left the aeroplane, which prevented accurate aiming, and engineers saw that to overcome this tendency it was necessary to construct the missiles so that the centre of resistance lay behind the centre of gravity. Any kind of a tail on the bomb would do what was wanted in this respect, and tails were accordingly fitted, but then came the problem of ensuring that the explosion took place at the proper moment. A little experiment soon overcame this trouble also, and the makers so arranged the balancing tails of the missiles that after the bomb had fallen some feet through the air a safety catch was released, with the result that the bomb became an ordinary concussion shell, exploding on coming into contact with any resisting body.

The German aeroplanes in their later raids carried bombs weighing 110 and 26½ lbs.; these were torpedo shaped, the largest measuring 5 ft. 7 ins. in length and 7 ins. in diameter. German airships carried both high explosive and incendiary bombs, varying in weight between 110 and 660 lbs. The body of the latter was made of thin steel filled with potassium perchloride in benzol, wax holding the stuff together. Tow soaked in pitch was wrapped round the bottom part, and running through the middle of the whole was a thermit-containing iron tube. An ordinary percussion cap ignited the thermit, which, because of the intense heat generated, set the whole bomb going, each pleasant little constituent doing its best to add to the pleasures of the night. Some bloodthirsty people, who were in London during a German air raid, were heard to express an impious wish that the Kaiser and the Crown Prince, before being strapped together and dropped from a height of 10,000 ft., should have one of these bombs attached *in situ!*

After a while the mathematicians attached to the armies began to plot out curves and charts for the bomb-dropper's benefit, and these, together with improved bomb sights, releasing gears and greater experience, did a great deal towards making for accuracy. As to bomb-dropping at night it is inadvisable to give any details, for although presumably the enemy knows as much about the work as the Allies, there is always an outside chance that he does not. As against this he has always made a point of specialising in night raiding behind the Allied lines so that he may be further advanced than the Allies themselves in this particular form of "strafing."

Considerable difficulty was at first experienced in housing the bombs taken up in the early machines. In the early days the observer preferred to have them in a small box, carefully packed to avoid the possibly disastrous effects of concussion, and convenient to his hand. A somewhat later development was to suspend the missiles rather crudely from various parts of the under-carriage and the wings—a dangerous practice which made it practically impossible for a landing to be effected without an explosion occurring. Later on designers improved the carrying apparatus, but further difficulties arose when the bombs which should have fallen clear of the machine caught on some part of the under-carriage and called for thrilling mid-air gymnastics on the observer's part in order to release them. The later machines of 1916 were fitted with very satisfactory bomb racks and releasing gear, which were practically forgotten by the pilots so far as their own safety went and which were very trustworthy and reliable in operation.

During the war reconnaissance flying developed so rapidly, and proved of such great value, that only experienced officers of the staff could appreciate the niceties of the work. On the day of great aircraft activity many squadrons and individual machines were detailed to particular jobs and each proceeded on the day's work without intense curiosity about other aircraft met with so long as they were not hostile. A pilot flying a long-range, two-seater reconnoitring machine, on starting, might have glanced upwards and seen a protecting convoy hovering some thousands of feet above him. To right and left other squadrons similar to his own and flying at the same height would be proceeding in directions different from his own over the enemy lines. Some 2,000 or 3,000 feet below, "spotting" machines would be at work signalling to the guns the effects of the firing; lower still, aircraft would be photographing the enemy lines; while still lower could be seen one or two daring machines gunning and bombing the enemy trenches and gun emplacements. Nor were these all the uses found for aircraft in modern war.

Tactical reconnaissance flying may be described as searching the area behind the enemy's lines to an extreme depth of 20 miles, while strategic reconnaissance flying may extend so far back into the enemy's country as 70 or 100 miles. The tactical aeroplane searches for

A SUNSET SILHOUETTE SHOWING A "BLIMP"—THE BRITISH NON-RIGID AIRSHIP —SCOUTING OVER THE MEDITERRANEAN.

A "DUD" OR UNEXPLODED BOMB

A ZEPPELIN BOMB

A ZEPPELIN STARTS ON A CROSS-COUNTRY FLIGHT "blind" positions of importance in the rear of the enemy lines, and makes a note of every movement and enemy activity likely to be of immediate importance. Quite a lot of fish, so to speak, comes to the net of the tactical reconnaissance aeroplane. Railheads, ammunition dumps, food convoys, bivouacs, headquarters and other places of importance are all searched for and noted by the eagle eye of the observer. In consequence the art of concealment is practised more. The Hun becomes quite expert in concealing his movements from Allied aircraft, and camouflage, or the art of concealing objects of value, became quite an art. Guns were painted to merge into the ground scheme, batteries were concealed by artificial foliage, and many other ingenious effects were thought out to deceive the observing aircraft. Only in times of very great pressure was it the German practice to move troops by road and in the daylight, his favourite hours for this work being at night and in the very early half-light of the first morning hour, when aerial scouting was difficult. Occasionally, however, it was essential that he should rush up his troops quickly, speed being the essence of the contract, and a few men killed by aircraft bombs were of less importance than the presence of more troops in the firing line. On these occasions the daring Allied pilots had quite a "joy day." Flying at almost dangerously-low altitudes, the machine-guns were turned on the marching troops who generally took to the nearest cover, the phantastic evolutions of the aeroplane minimising to a very great extent the possibility of pilot or observer being shot down by rifle or machine-gun fire from the ground. Many instances were recorded of Allied aircraft following railway trains, bombing the engine and carriages until the train stopped and the troops descended and scurried across country to shelter while the machine-gun of the hunter was brought to bear with telling effect. There is a classic story in the Royal Flying Corps of an impatient pilot returning from a flight meeting the staff car of a Hun general and following it along the road, bombing and machine-gunning it until the Hun general and Hun chauffeur took to their heels and ducked under cover like startled rabbits. The pilot returned and wrecked the car with a bomb!

Strategic aeroplanes are constructed with a view to undertaking longer flights. They are bigger machines than the tactical craft and have a greater cruising capacity and a more powerful engine, the extra power being needed so that the speed may not suffer. Information sent back by these machines is carefully collated and cross-checked by the officers of the General Staff. So valuable did this strategic scouting become that it was necessary to evolve a special course of instruction and training for the observers, who were required to gain a working knowledge of practically every branch of military work. In addition to being able to appreciate the importance of fortified positions, rolling stock, railways and stations, roads, ponds and woods, the powers of deduction had to be cultivated to a remarkable degree. A column of smoke had a meaning which must be read; a trampled road, for example, or suspicious-looking trees that never grew in the ground but were manufactured in a workshop, each and every item which the casual person would overlook entirely, had a story and a meaning for the aircraft observer. In addition to finding out what the enemy did not wish him to know, the strategic observer had to be wise enough not to be deceived by the devices of the enemy calculated deliberately to deceive him. The news-seeking scout is essentially not a fighter, although he must have a moderately high speed and some means of attack and defence. It is far more important that a scout should return home with its information than that it should risk destruction and the loss of the information gained. If attacking enemy aircraft can be defeated and driven down, however, so much the better. Therefore means of attack and defence must be provided. The modern tendency is to arm such machines lightly and to protect them fairly heavily. So far as was possible without reducing speed and lifting powers to any great degree, the vital parts such as controls, fuel tanks, engine and also the pilot's and observer's seat, were armoured with chilled steel capable of turning aside machine-gun bullets and shrapnel fragments. A direct hit by a shell must always destroy an aeroplane, no matter how heavily it be armoured, just as a well-placed shell can sink the mightiest Dreadnought.

Whenever possible scouting aeroplanes were accompanied by fast-flying machines whose duty it was to drive off threatened attack by hostile aircraft. Experience taught that squadron flying in strategic work was preferable to scouting by single units, for there is then more opportunity to check the reports made and a greater chance also of one pilot discovering what another misses. Views of the same position are obtained from slightly different angles, and while the squadron is flying in formation it is better prepared to resist attack.

War experience proved that the "maid-of-all-work" aeroplane, although extremely valuable, compared unfavourably with the "special purpose" machine. No commander has yet, however, been in the enviable position of having as many machines of every type as he can use, and so, often enough, machines are used for different work. Despite the increased rate of aircraft production, it is doubtful whether supply will ever equal demand, for, naturally, any commander who once realised the value of aircraft would indent for thousands on thousands of machines and pilots, if he thought there was the slightest chance of getting them.

The "spotting" aeroplanes, whose particular duty it is to report to the artillery the exact effect of the firing and to check the calculations and ranges of the artillery officers, were soon all fitted with wireless apparatus—as, indeed, practically every machine but the fast single-seated fighters was, after the first two years of war—and the old primitive signalling methods, such as the use of coloured lights and air evolutions, have gone for ever. The British developed wireless telegraphy for aircraft to a greater pitch than the Germans. The latter, however, started the war with a great deal in hand, for the German airmen were well trained and had had much experience, whereas the Allied pilots had to take the air and find out all about it for themselves, not on manœuvres, when the operation was unattended with danger, but in actual service, when the ever-ready anti-aircraft "Archie" was hungry for spoil. The "spotting" aeroplanes led to great improvements in long-range guns, which previously were only occasionally used, and then more in the hope that lucky shots would terrorise the enemy. Nowadays long-range shooting is a cold, mathematical business which is part of the gunner's ordinary training and which enables him to wipe out any spot against which his fire is directed as completely as though it had been wiped over by a monster sponge. Superiority in "spotting" soon passed to the Allies, and probably this was due to that mental distinction between the peoples which led them to take such a different view of the use of aircraft in war. The German is a methodical animal, and he is a scientific fighter, but cowardliness has no part in his composition despite the silly reports which occasionally appeared in the Allied Press. For some reason best known to himself the German did not, as a rule, run anything like the same risks with his aircraft as the Allies. Occasionally a high-flying black-crossed machine flew into enemy territory on a reconnaissance or scouting flight, and now and again photographing machines also made their appearance, but the proportion of flights of all types of machines over enemy lines was always in the near neighbourhood of two to one in favour of the Allies. Some war correspondents would have had their readers believe the Germans flew in considerable numbers and in battle formation because he was afraid to fly singly. As a matter of fact, the German did nothing of the sort. He is a scientific fighter and realises that he had a much better chance of aerial victory when he could pit two machines against one, and when he had the machines he used them. In the future the "spotting" aeroplane will be so heavily armoured as to make it practically invulnerable to anything but direct hits by shells. Such a machine will have no great need for speed, excessive height or engine power, although the bigger the machine the more powerful must the engine be in order to sustain the increased weight of the armouring.

When fighting in the air first began, the pilots took up rifles and revolvers, but the chance of bringing down an enemy machine with a single bullet was exceedingly slight. The machine-gun was an improvement; it enabled a stream of bullets to be directed against the enemy craft, and the chance of hitting some vital part of the pilot was thereby greatly increased. Developments in gun mountings, which enabled the gun to be fired from practically any angle, and the multiplication of the guns, increased the power of the offensive to a still greater degree.

In the beginning it was not generally believed that much individual fighting between aircraft would take place. The idea seemed too crude and the chances of the respective aircraft meeting too small. Probably in some of the older wars, where manœuvring on a large scale was practised, something might have been said for this theory, but when the German and Allied armies locked on the Western Front, practically within arms' length, naturally the opposing aircraft could hardly take the air without meeting each other. There were few air scraps during the years 1914-15, but in 1916, at the battles of the Somme, individual fighting increased in intensity. Star pilots arose who added numbers of victims to their score, and these were not confined to any particular side, for both the French, British and Germans had their pilots whose air victories numbered 40, 50 and 60, and the brilliant individual fighter who, possibly, was merely a good average pilot when it came to reconnaissance flying or spotting, was a recognised feature in the air fighting by the end of 1917. Later, however, the individual fighter became merged in the flying squadron, on the theory of greatest good to the greatest number, but the individual stars always, when possible, fought their battles unaided. The Germans put up their famous flying circus, which played havoc with the Allied aircraft for a time and which was only suppressed when the Allies received quicker and more powerful fighting machines and sent them up in squadron formation.

Aerial photography proved to be one of the most interesting developments in the world war. There is some amount of satisfaction to be found in the fact that the Allies achieved a higher degree of skill in this direction than the enemy. At first the cameras used were of the ordinary long-focus type, and many experiments were made with various automatic plate changers and similar apparatus. Experience demonstrated that the simpler the camera the greater the success, and the later photographing machines were equipped with cameras built into the fuselage and of the wide angle, long-focus type having iron frames. These were operated by the simple pulling of a lever, which exposed and removed the plate, and snapped a new plate into position, with little chance of error. In one branch of war photography the machine flies over a given area and the resultant pictures obtained give, by means of a small overlap, removed in the finished picture, a continuous view of the area photographed. The enlarged prints show the commanders very vividly the condition of the enemy line. Pictures of another kind were taken to show the results of bombardments, and these proved of the utmost value. Speed is the thing the pilot must bear in mind. Photography for the illustrated papers in peace times was credited with some rapid work, and the cinematograph has also put up one or two records in this direction, but the work of the photographic section of the Royal Flying Corps put these in the shade. In less than half-an-hour a photograph can be taken of an enemy position, a flight of some miles made, and the finished and enlarged print presented to interested staff and artillery officers. Curiously enough the camera shows up some things not seen by the naked eye or even through long-range glasses. For instance, a body of men may have crossed a grass-grown area, and if they have marched with care, at 5,000 or 6,000 feet the marks of their going would not be noticeable to an aircraft observer. A photograph of the field taken within a few hours of the movement would leave no doubt as to the troops having marched over. Before any big offensive, thousands and thousands of photographs were taken by the army on the offensive, and how eagerly the pictures were scanned and checked and the results of the bombardment and the over-night bombing noted none without actual experience can fully appreciate. Maybe there was an isolated strong point somewhere in the enemy defensive system, and for the benefit of the advancing troops the part is treated with twenty minutes of high explosive. Afterwards a photograph is needed to show if the position is still intact or what damage has been done it. The print shows the stronghold to be practically untouched. The bombardment is repeated, and so the work goes on until the staff is satisfied.

The aeroplane pilot prefers height just as the seaman prefers the open sea. Height means power to manœuvre, and it is extraordinary how many times crippled machines have returned to the safety of the friendly lines when trouble developed at what the pilot would call a satisfactory height. Aeroplanes are so designed that they have a gliding angle of between 1 in 7 to 1 in 10. In other words, with the engine shut off the machine glides towards earth at the rate of 1 ft. in 7 ft. to 10 ft. Assuming, then, that for some reason or other the engine goes out of action when the pilot is at a height of, say, 15,000 ft. it becomes possible for him, barring attack from hostile aircraft, to glide for many miles before descending to earth. In the early machines it was necessary for the pilot constantly to watch for wind gusts and other disturbing elements, and to correct their effect on the machine by the use of his controls. Nowadays, however, designers have so much increased knowledge and experience that the automatically stable machine is an accomplished fact. The pilot can ignore his controls for long periods, and should any atmospheric disturbance affect the machine in any way its design is such that the movement is immediately corrected. The inherently stable machine returns always to its correct gliding angle, and the 1917 aeroplanes, if taken up to a height of 10,000 ft., and turned upsidedown or sideways and flung into the air, would, after falling for some little distance, come to a level keel and resume the proper gliding flight, descending at an angle of 1 in 7 to 10. In actual flight the pilot may stall the machine suddenly, stand it on its tail, on its wing tips, or indulge in a vertical nose dive, but, if left to itself, the machine automatically recovers and flies again on an even keel. Height, however, is necessary for this manœuvring, for a machine does not pull itself out of a nose dive in 50 to 100 ft. In case of a sudden dive or sideslip the machine flying at low heights is liable to crash to the earth before the power to return to proper flying position can be exerted.

This automatic stability was taken advantage of by those designers who produced single-seated machines in which the armament consisted of a machine-gun firing through the propeller. The guns on these machines were not of the swivelling type, but were clamped in position, aim being taken with the machine itself, which continued in flight while the pilot fired. The power of the modern aeroplane to perform all sorts of complicated manœuvres in the air was taken full advantage of in air fighting, and although before the war the man who deliberately looped the loop or stood his machine on a wing tip was regarded as an adventurous fool asking for trouble, later on no pilot was considered reasonably efficient unless he had every air manœuvre at his fingers'-ends. Looping, tail sliding, nose spinning, diving, stalling, every trick in the vocabulary of the airman was used in "air scrapping." Most machines have a blind spot, probably a position from which the pilot has not a clear field of fire, or from which attacking hostile craft cannot be seen, and the problem of designers was to produce machines giving an all-round view and field of fire under all circumstances. The speeds achieved by the single-seated fighters in the fourth year of war were stupendous.

When the Allies began to develop the artillery barrage in a scientific way it was necessary for the guns three or four miles behind to know exactly the effect of their firing. Co-ordination between guns and infantry was, therefore, an essential factor in the scheme. Theoretically the idea was for the artillery to put up such a smashing barrage that every part of the defence was smashed out of all recognition, dug-outs knocked in, emplacements powdered and wrecked, and the fire trenches piled up into heaps, and everything worked by the clock. The heavy barrage opened at seven o'clock and at eight o'clock exactly the range lifted by 100 yards and the attacking infantry crept forward and took the first line of enemy trenches. At 8.15 the range was again lengthened by 100 yards, and a second wave of troops passed over and took the second trenches; the battle continuing in this way until the fixed objectives had been reached. Unfortunately, it occasionally happened, despite all the spying of the aeroplanes, that some stronghold was left in a position to inflict casualties on the attackers, and some means of conveying information about this unsuspected obstacle to the guns was needed. The aeroplanes pointed the way out of the difficulty. "Contact" machines the aircraft so engaged came to be called, the name being obviously coined because they were a means of contact between guns and infantry. These machines, flying at incredibly low heights, so low sometimes as 100 and 150 ft., kept in touch with the advancing infantry, and having a considerable view were enabled to signal back to the artillery exactly how affairs were progressing. When the infantry experienced an unexpected check the men took what cover was available, the aircraft signalled the range and location to the guns, and salvoes of shells were put down on the obstacle. These contact machines were available also for scouting in the immediate vicinity of the enemy's lines, and could signal information of any attempted concentration of troops for a counter attack, the guns being then enabled to disperse such a concentration without delay. There was a big and certain element of danger in this low flying, for an engine failure would crash the machine to the ground, and the aeroplane and pilot were subject at all times to rapid fire from the enemy's rifles, machine-guns and light field guns. Their speed and the machine-guns and the bombs carried made them quite formidable opponents at close range, and there is also this to be said for the low-flying aeroplane: that a big calibre gun, having a high trajectory, cannot reach it; while when the machine is moving in undulating or wooded country it has flashed into view and passed out of range almost before a rifle can be lifted against it.

Startling as the new offensives developed by the Allies were, they would have been quite impossible without the aid of aircraft. Week by week the need for machines increased as new employments were found. Many competent authorities are now of the opinion that in the future there will be an air cavalry comprising tens of thousands of aeroplanes, which, immediately on war being declared, will fly over enemy country and bomb the towns practically out of existence. We shall see.

# THE SEAPLANE AND AIRSHIP AND THEIR USES

## CHAPTER VI

### THE SEAPLANE AND AIRSHIP AND THEIR USES

THE seaplane is a weapon which must have peculiar attractions for nations having a coastline and any pretensions to naval might. Because of the simple truth of this statement it follows, almost as a matter of course, that the British Admiralty needed a lot of convincing. The same explanation of this official conservatism holds good for the navy as for the army. To have accepted the claims of the aircraft enthusiasts would have meant considerable revision of all the existing plans, and, because admirals are not created at the ages of thirty and forty, most of those in power were too old to learn new tricks. The difficulty of convincing a British admiral of 1914 that a fleet of seaplanes or a few submarines, commanded by officers with less than a quarter of his sea-going experience and only half his age, could harass and annoy him and keep him to harbour with his squadron of battle cruisers, or sink his ships if he put to sea, can easily be imagined.

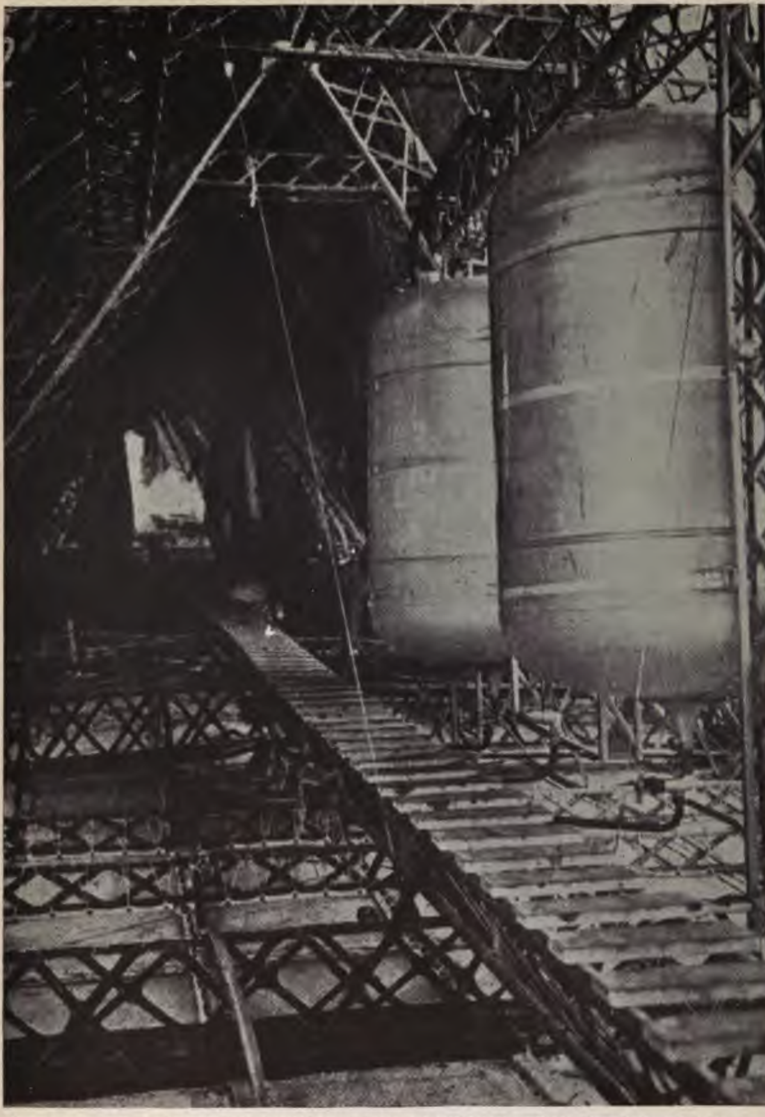
At the commencement of the war the naval authorities were only just beginning to realise the possibilities of the seaplane, and less than two years later it was agreed that without aircraft the British Navy had about as much value as a hole in the floor. The German Navy was no better off at first, and in the purely naval tussle of the opening weeks the British Navy won, hands down, for the seas were swept clear of enemy ships in quicker time than had ever been hoped for. Remembering, however, the damage done by the few isolated raiders that did escape before they were rounded up, there can be no reasonable doubt that had it been possible to do so the Germans would have sent out every unit of their navy to take even an outside sporting chance of getting through the cordon. Only aircraft made it possible to maintain ceaseless watch and guard, for there were not enough ships in the world to police the North Sea alone if ships were all the Allies had to rely on. Day by day the air patrol carried out its work. There was not a mile of the British coastline—and very few German—that was not under constant watch. The seas were sectionalised, and in each square the air and water patrols swept backwards and forwards, around and across. A hint of danger, a suspicious occurrence, and the wireless got to work and the patrols closed in. Very, very occasionally the enemy risked a lightning raid. Very, very occasionally he got in a blow and returned safely. More often he did not. Of these things, however, the public heard little. Sea power is silent and remorseless.

No great progress had been made in the development of the seaplane before the war. One or two private firms had built a number of machines; the German Admiralty, it may be remembered, had bought two—a Sopwith and a Wight—which were exhibited at the Aero Show in 1914, and a number of others were experimenting with various designs. Adequate engine power and suitably-designed floats were the chief difficulties confronting the builder. The floats had to be strong enough to stand a buffeting in comparatively heavy seas, have buoyancy sufficient to sustain the weight of the wings and engine when the machine was at rest in the water, and be so shaped as to afford the minimum of resistance when the transference from water to air was made; conversely, they had to present a suitable surface for returning to the water at the end of the flight. The need for greater engine power in seaplanes may easily be demonstrated: an ordinary rowing boat may be pushed through the water with slight pressure, but to lift it clear from the water needs the combined effort of several strong men. The floats and under-carriage of a land-flying machine, the lifting power necessary to hoist the floats from water to air, dictated a bigger wing spread, the engine itself needed to be more powerful, the fuel tanks of greater capacity, and all these and other considerations meant an increase in the total weight of the seaplanes. So the craft were bigger than the aeroplanes. Yacht builders eventually evolved suitable floats, aeroplane constructors designed satisfactory under-carriages, and the engineers produced engines developing horse-powers far in excess of the wildest dreams of the early seaplane experimentalists.

Credit must be given to Lord Northcliffe's newspaper, the *Daily Mail,* for its encouragement of the machine prior to the war. Indeed, when the war broke out a seaplane race round Great Britain, for which a prize of £5,000 had been offered by the paper, was actually under way. The machines built for this event did well in war service, and, apart altogether from the fact that it is more than probable that they would never have been built at all without this generous inducement to the constructors, there remained the extremely valuable experience gained in their building—experience which must have been worth very many thousands of pounds to the Allied cause. It was hoped that the race would demonstrate to the British Admiralty the value of the seaplane; as it happened the hands of the Admiralty were forced without so much as a "by your leave."

In its action the seaplane has much in common with the aeroplane. Both are set in motion by the action of the propeller or screw which pushes or draws along the machine at an ever increasing speed, until at last the rush of air under and above the wings exerts sufficient pressure to lift it clear of the earth or water and into the air. Differences of opinion exist, of course, as to the best type of under-carriage. The desirable features are simplicity, strength with great elasticity in order to take up the shock of landing, and the least possible amount of exposed surface when in flight. Aeroplane builders, although their under-carriages differ much in detail, have no option but to fit wheels for the run along the ground, and to this extent all designs are similar. Seaplane constructors, however, have evolved two totally different types; the first, known as the twin-float, is exactly as the name implies, and has floats of suitable shape attached to the under-carriage in the place of the wheels of the land-flying aeroplane. The second has received the general title of "flying boat." This latter carries its engine, crew and armament in a single cabin slung centrally below the wings. Very powerful craft of this type have been evolved during the war, and although had been discovered and applied—even the raiding aeroplanes made a wide detour to avoid Dunkirk. But with the most carefully-laid plans in the world the German aeroplanes now and again ran into Allied machines from Dunkirk and from seaplane bases on the British coast, with the result that the hawks paid the penalty to the eagles. The submarine can be picked out from a height even though it be submerged. A similar thing happens when, if one is looking into a river from a bridge, lurking fish, quite invisible from the bank, are plainly seen. The seaplane pilots were fully aware of the fact, and numbers of U-boats have failed to return to their bases in consequence.

Some competent authorities held that the seaplane was and is of the greatest value as a scout for the battle and cruiser fleets. A seaplane took news to Admiral Beatty, in charge of the "Cat" squadron (battle cruisers), at the time of the Jutland battle, that the whole German Fleet was out. The news was of vital importance to the British Admiral and led to a change of plans which, but for failing visibility, would inevitably have led to the complete destruction of the Hun fleet. The naval Zeppelins informed Admiral von Hipper of Beatty's strength, and supplied news of the advance of Sir John Jellicoe's battle fleet in time to enable von Hipper to



INTERIOR OF A ZEPPELIN SHOWING THE ENORMOUS TWIN PETROL TANKS AND THE "CATWALK" WHICH RUNS PRACTICALLY FROM END TO END OF THE STRUCTURE

THE FRAMEWORK AND BOMBS OF A ZEPPELIN BROUGHT DOWN
IN FLAMES AT SALONICA

break off action and dash for his home base before the big British ships could arrive in full strength. Consideration of the respective value of the airship and the seaplane in naval scouting is the next step. The former can keep the air for a longer period, and its cruising radius is much greater; it carries heavier guns and a greater load of bombs; and for long periods in calm weather can husband its fuel by shutting off the engine and drifting with whatever wind there be. Its outstanding disadvantages are that it must return to a fixed base, that its huge bulk makes it more vulnerable to hostile attack and sudden storm, while, should it be necessary, in manœuvring to avoid any of these, to rise to a height greater than the level of flotation, its powers are crippled for the remainder of the cruise.

The airship rises owing to the lifting power of the gases contained at atmospheric pressure in its envelope, or, to put it another way, the ship displaces a volume of air greater than its own weight. As height increases, the density of the air, because the atmospheric pressure lessens with height, decreases, and so, obviously, the ship will rise until it reaches a point when the volume of air displaced is equal in weight to that of the ship itself. Mechanical means must then be adopted to force the ship higher. The decreased air pressure on the envelope causes the gas within it to expand, and, although the modern airship has reserve gas space within its outer envelope into which some of the expanded gas can be directed, the time comes as the ship continues to rise, when some of the gas must be exhausted into the atmosphere unless the whole envelope is to burst from internal pressure. When the ship returns to a lower level it is impossible for it, owing to the amount of gas lost, to reach the same level of flotation as before, and when, through loss of gas, the weight of the air displaced at sea level is approximately equal to the weight of the ship itself, all buoyancy is lost. No further ascent is then possible until a fresh supply of gas has been taken in.

This weakness of the airship was dramatically illustrated on the occasion of the Zeppelin raid against England in October of 1917 when, caught by a storm in the higher air levels, the ships, unable to fly lower with safety because of the English anti-aircraft guns, rose to an enormous height to escape both dangers, and lost so much gas that the ships became unmanageable, and, in this condition, were unable to set a course for their Belgian bases, drifting over France at a low height some hours later and being either shot down or captured by the French. The airship is handicapped in a fight with aeroplanes owing to less speed in flight and slowness in manœuvre, its only advantage here being the quickness at which it can rise to the level of flotation. The highly inflammable gas in the envelope holds possibilities of a sudden and fiery ending when an incendiary shell, fired either from an attacking aeroplane or from the ground, explodes anywhere in the near vicinity. Some very ingenious ideas of this sort were used by the Allies during the later period of the Zeppelin raids, and about ten millions of people in the London district used to look forward to thrilling firework displays from properties supplied by Wilhelm & Co., the whole being stage-managed by British Aircraft.

As a naval scout the seaplane also has disadvantages. It must have sleeping accommodation either on battleships or in a special mother-ship, for, when a flight is finished, the heavier-than-air machine must descend; it cannot hover for prolonged periods like the airship. The real object of a battleship, that of serving as a floating big gun fort, is circumscribed to the extent of the accommodation offered to the aircraft; if the latter method be favoured a special type of ship is needed, an expensive job at best. Against this can be set the cost of the airship sheds, which, no matter how ingeniously they be constructed, cannot accompany a fleet to sea. The mothership, however, can, and should be big and fast enough to accompany a battle fleet on a world cruise, of a speed sufficient to maintain station, and of an armament heavy enough to repel attack from anything but capital ships. The seaplane mothership can be equipped with repairing facilities and a full battery of spares, so that numbers of seaplanes can be housed. The combined cruising radius, in this case, would be greatly in excess of that of an airship, while, obviously, a dozen seaplanes could scout in more directions than an airship, and their greater speed is another important factor; nor would the loss of anything up to 70 or 80 per cent. of the machines carried by a mothership necessarily mean that the fleet commander was quite without news, for the information brought by one machine could be as full as that brought by a big airship, and the actual loss of money and trained men would be lighter.

The failure of the Zeppelin as an offensive weapon to the end of 1917 must not, however, be regarded as the complete failure of the giant airship, for the future will probably bring immense improvements. Because the famous paddle steamer the *Great Eastern* failed commercially was no condemnation of the big power-driven ship as a type. The idea was, and is, perfectly sound, but the first few attempts to carry it into practice were wrong. It is more than probable that the same thing will happen in the case of the airship.

The British used big numbers of airships of one sort or other during the war, including the "S.S." (submarine scout), vulgarly the "Blimp." The "Blimp" is a cross between balloon and aeroplane; its upper half (gas bag) is about 150 feet in length, with a diameter of about 30 feet, and its lower structure is practically that of a medium-powered scouting aeroplane. The oiled silk bag is cigar-shaped, and has a capacity of about 70,000 cubic feet, giving a total lift of about 5,000 lbs., while the safety height is in the neighbourhood of 7,000 feet. The two-bladed propeller has been replaced by a four-bladed screw, and the speed has been reduced by gearing to about 700 r.p.m. A small blower engine, independent of the main power unit, serves to keep the envelope inflated with air in order to preserve the designed shape—a necessity in the case of non-rigid airships. The average speed of the "Blimp" is about 35 m.p.h., and it can carry pilot and observer, together with a load of bombs, and fuel for a ten-hours' flight at cruising speed. In addition to its bombs the craft is fitted with wireless and, when necessary, with cameras and observing instruments. In the British Navy they say the "Blimps" had a bigger bag of U-boats to their credit than all the other devices put together. Hundreds of these ships keep watch and guard round the British and French coasts, and every visitor to coast towns saw them in dozens. They are economical to build and maintain, and, in their particular sphere of activity, were of the utmost value. There is a wicked story to the effect that the "Blimps" came about because a gas bag was the only way to get one of the aeroplanes designed by the Royal Aircraft Factory off the ground! The story ought to be true, but probably isn't. In any case there is a big future for this type of airship as a sort of quiet family craft. A larger type of airship which went further afield than the "Blimp" came to be known as the Coast Patrol ships, shortly the "C.P." These did excellent work in locating mine fields, assisting the armed patrol in the search for U-boats, keeping a watchful eye on German naval movements, and acting as convoys to merchant ships. There were not enough suitable craft in commission at the beginning of the war to supply all the convoys needed, and the development of the seaplane and smaller airships for this purpose was one of the things not foreseen by the German military leaders. The aircraft took over their charges from the light cruisers and destroyers anywhere between 50 and

150 miles out to sea. The British authorities made spasmodic attempts to build one or more big airships of the rigid type, and there were rumours that one of the captured Zeppelins had been rebuilt and put in commission. It seemed, however, that the authorities were unable to make up their minds, and work was sometimes rushed ahead and again was stopped, the top and bottom of the matter being that airship building and piloting is an extremely ticklish job calling for experience, specialised training, and ample constructional facilities. The British authorities had neither one thing nor the other, and they were apparently unable to distinguish the types of German ships to fall into their hands. Some official ass, jealous it would seem of the Waterloo fame of Mr. Bill Adams, made the British Government the world's laughing-stock by discovering that the extensive employment of wood in a German Schutte-Lanz airship indicated a shortage of aluminium in Germany, when for years this maker's general practice had been to build his ships of wood. Whatever else the Central Empires were short of it was certainly not aluminium, which, by a special process perfected during the war, the Boche produced by the hundred tons.

The French were never lovers of the airship. It was too crude and limited as compared with

[illegible]

[illegible]

Interior of Zeppelin showing framework. [illegible] Catwalk from end to end of airship. [illegible] Wire arrangement [illegible] and supporting [illegible]

[illegible] containing Engines driving separate propellers.

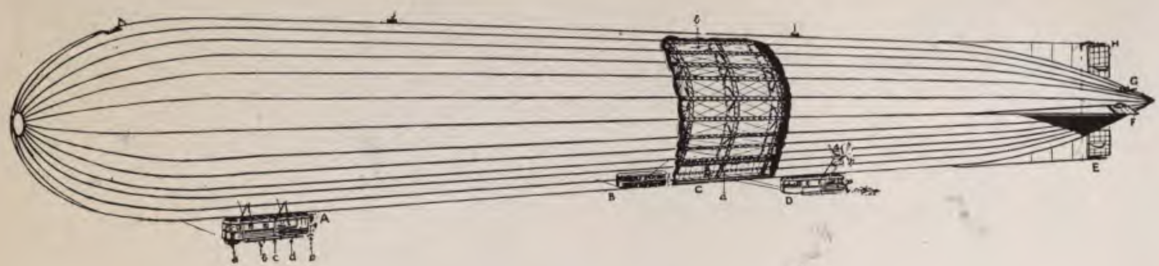
[illegible] [illegible] Aft Machine Gun.

[illegible] [illegible] Forward Machine Gun.

the heavier-than-air machine, but this is not to say that the French did not experiment largely. They did, and with a varying amount of success. Some of the airships fell in the streets of towns, some blew away to sea and were never again heard of, but others did quite a lot of satisfactory work, and, from time to time, other countries, unable to build airships of their own, bought typical French productions. No other nation built airships of any practical or outstanding merit.

Airships may, along broad lines, be divided into two classes: the rigid and the non-rigid. The former is bigger, its shape in the air is retained by a framework which may be of wood, aluminium or other light metal or wires, or a combination of both. Over this framework is stretched the outer envelope, while the interior is filled with a number of balloonettes which vary in size and shape according to the cross section of the part of the ship in which they are fitted.

A general description of the construction of the latest type German airships to fall into the hands of the Allies will not be out of place here. The first to be brought down in flames in England was a Schutte-Lanz, and was a pre-war model; its hull was a true streamline shape, and the main members consisted of fifteen circular




THE CARS AND GAS-BALLOONETTES OF THE ZEPPELIN AIRSHIP

*Diagram of a Zeppelin*

A—Forward Gondola. *a* Captain's Cabin; *b* Wireless Room; *c* Division between Wireless Room and Engine Rooms; *d* Engine Rooms; *e* Pusher Propeller.

B—Port Gondola containing 240 H. P. Six-Cylinder Engine. There is a similar Gondola on the Starboard side.

C—Interior of Zeppelin, showing framework. *a* Catwalk from end to end of airship; *b* Wire arrangement containing and supporting balloonettes.

D—After Gondola containing Engines driving separate propellers.

E F H—Rudders. G—After Machine Gun.

I J—Ventilators. K—Forward Machine Gun.

*Photograph by courtesy of the "Illustrated London News"*

PROBATIONARY FLIGHT OFFICERS LANDING A KITE BALLOON

AN ARMY OBSERVATION KITE BALLOON

*Its curious shape* is designed to secure steadiness in the air wooden hoops set transversely and at approximately equal distances along the hull; spiral latticed wooden trellis work held the members in position, and the whole was bound with steel wire in great quantity. The Schutte-Lanz has no keel, the weight of its cars being distributed over the whole of the construction. Each car carries a Maybach motor of 240 h.p., which drives, through a clutch and reduction gearing, a "pusher" propeller located at the stern of the car and giving a speed of 53 m.p.h. There are no means of communication between the members of the crew housed in the respective cars other than by telephone. The cubic capacity of the 1913 Schutte-Lanz ships is about 921,000 feet, giving a lifting capacity of 17,600 lbs., and the gas bags are of unusual shape to fit the interior and to allow for the strengthening cross-sections and braces. The length of the ships is 470 feet and the diameter 60.5 feet. Two of the bags are uninflated at the beginning of a voyage, and as the ship rises the gas expands and flows, assisted by a circulating pump, into the empty bags until, at a height of between 6,000 and 7,000 feet, all the bags are filled. When the Germans standardised their airship construction for rapid building it is believed that the best points of the Schutte-Lanz and the Zeppelins were incorporated in the one type of ship, and it is true that the super-Zeppelins were superficially very similar to the wooden ships.

As to the constructional details of the later Zeppelins, for all practical purposes the L33 was typical. The official dimensions supplied of the L33 gave the length as 640 feet, the maximum diameter 72 feet, the approximate capacity 2,000,000 cubic feet, the gross lift 56 tons, the total horse-power 1,300-1,400, and the speed as about 55 m.p.h. Like other official figures, some slight adjustment and correction are needed to arrive at absolute accuracy. Examination of the framework of the wrecked Zeppelins showed many evidences of standardisation and hasty construction, and it is evident that the enemy has produced numbers of very special machines for bending, shaping and riveting the metal structure of the ships. Some of the lay journals have made ridiculous suggestions that, after a voyage, mechanics take a dustpan and brush and sweep hundredweights of rivets, loosened during the voyage, from the interior of the ship.

An inverted keel, "Λ" shaped, runs from end to end of the hull, very similar in its general construction to the other latticed girder work in the structure, the "Λ" projecting inwards. The two bottom main longitudinals form the base of this keel, which serves as a "cat-walk," by means of which, if due care be exercised to avoid stepping off the girderwork and through the fabric of the envelope into space, the crew can pass from each compartment into the others. Also, this latticed "cat-walk" stiffens up the construction, gives storage space for the fuel and oil, and provides anchorage for the cars with their complements of engines, guns and crews. The outer hull is covered with heavily-varnished cotton fabric, and a space is left between this covering and the inner gas bags, which are separate to each compartment and which are shaped at the bottom to accommodate the "cat-walk." Automatic and hand-controlled valves are fitted for regulating the buoyancy of the ship. Four cars are fitted. In the foremost are the controls for the water-ballast tanks and the hand valves, and, this being the commander's car, there are also the engine-room telegraphs and the controls for the electrically-operated bomb-dropping gear. Telephones and speaking tubes for the other compartments are also led to this car. The rear car is slung about 200 feet from the stern, and the dead weight of the rudder and elevating gear takes what lifting power there is. This rearmost car contains three engines, each of 240 h.p. Maybach six-cylindered water-cooled type; the rearmost centrally-located motor drives a geared-down propeller of the "pusher" type, while the others, through very cleverly-designed bevel and shaft gearing, drive propellers housed in brackets and located well up on the sides of the hull. The careful streamlining of the propeller brackets, which are built up of aluminium tubing—the placing of the three-ply wood used gives the desired streamline—the attachment of the brackets to the hull by ball-joints, the arrangements made to absorb propeller thrust, and the stiffening of the whole by cross-braced wire cables, also covered with wooden fairing, are extremely interesting specimens of German love of detail and thoroughness. The German practice of sheathing the tips of the propellers with brass edging and overcoming any tendency of centrifugal force to throw this off by running binding wire from the metal edge of one blade, right through the boss to the metal edge of the opposing blade was ingenious. The two smaller cars are about 18 feet in length, and are in the main simply engine-rooms, although each is fitted with a machine gun. They are slung side by side by girder work from the hull with the "catwalk," whence they are reached, in between and approximately amidships. Each contains an engine of similar type to those contained in the other cars, and these drive through a clutch and reduction gearing; there is also a hand-brake to contain the propellers in the horizontal position when landing—a "pusher" type propeller. Each of these central cabins is also provided with red and green navigation lights.

There has been no fully-accepted ruling as to the load of bombs carried, and no doubt this varies according to the distance of the threatened area from the airship base, for reserve fuel and oil means less bomb accommodation. For short voyages up to four tons can be taken, but for longer journeys anything up to two tons of bombs would be usual. As to armament, a corrugated aluminium platform let into the top of the hull about 100 feet from the bow provides accommodation for three machine guns of fairly heavy calibre, a second gun platform is provided at the rear immediately above the extreme tail and aft of the rudders—about the most thankless job on the whole ship for the gun operator, located as he is on a lonely platform, reached by a most precarious climb, right on top of the structure, and over 200 feet from the nearest of his fellows!—while six further guns are divided between the respective cabins. The full crew numbers 22 men. Various observers whose statements are worthy of credence maintain that bigger ships, having a power plant consisting of seven or eight 240 h.p. Maybach motors, giving a speed of 68 m.p.h., a volume of over 2,400,000 cubic feet, with a total lift of 77 tons and a useful lift of 28 tons, maximum altitude 16,500 feet, mounting ten machine guns in all, and carrying four tons of explosives in addition, have already made their appearance. Indeed, there is a widely-held belief in military circles that the Zeppelins shot down in the raid on November 28th-29th, and which dropped into the sea off Durham and Norfolk, were of this type.

The non-rigid ship is smaller and lighter, and while the envelope is designed to afford minimum resistance to the air, its shape is maintained in flight by the gas contained within it. Room for expansion or contraction of the gas is provided by fitting an air bag inside the main envelope which can be filled with air from a fan or blower driven from the engine, while the rush of air caused in flight is also taken advantage of for the same purpose. Engine and crew are contained in a cabin or fuselage slung beneath the ship. The cruising capacity of the non-rigid airship is considerably less than its bigger rival, and it is also more of a fair-weather craft; on the other hand, it is cheaper to build and maintain, its housing needs are not so extravagant, and, having no rigid framework, it can be packed within a space which enables it to be transported by sea in any ordinary cargo ship. During the war great improvements were made in travelling gas-producing plants for field use, and, because of these, armies were able to take with them both non-rigid airships and kite balloons. These latter were also developed to a great extent during the war. They were originally conceived as an aid to long-range artillery firing, and were used by the Japanese at the siege of Port Arthur. Their greatest disadvantage was instability in the air, where, subject to every vagary of the wind, and held by a cable to the ground, they bumped and leapt and spun and dived sickeningly in giant contortions until even the most hardened sea-dog was reduced to a limp, bruised and battered bundle in the course of a few minutes in the observation car. The object of the later inventors was to design a balloon which, despite its being held to the ground, would remain steady in the air even in fairly windy and changeable weather. By changing the shape and fitting stabilising fins some good was done, and later on wind scoops proved an even greater improvement. The provision of a streamlined surface was something of a problem, but even this was more or less successfully attempted, and, as other improvements were made in hauling gear and transport lorries, the kite balloons were more and more used. Each army organised a special section, and on all fronts a long row of these grim spies

## CHAPTER VII

### THE CONSTRUCTION OF THE MODERN AEROPLANE

NOT for some considerable time did the manufacture of aeroplanes have any attraction for the business and commercial world. The early pioneers may, somewhere in their make-up, have had business instincts, but the work of producing machines that would actually fly took up all their time and most of their money. Some, naturally, visualised the prospects opening up for the aeroplane once the initial difficulties were overcome, and perhaps this vision of a tempting future had its effect in making them more determined to go on with the work. Those who could see so far ahead were obviously men of imagination and action; and these two qualities combined lead, in commercial life, to big things. In France there were men like the Farmans and Blériot, in England there was A. V. Roe, and in the United States men like the Wrights and Curtiss. All these and others were pioneers of the aeroplane who are now business men with big commercial and financial interests. Not always was it so, however, for in the early days would-be flying men had perforce to be jacks-of-all-trades and, contrary to the old saying, masters of a good many. They practically built the first machines with their own hands; their workshops were old barns and sheds, or iron-roofed constructions knocked up without regard to appearance; low cost was the main governing factor. Carpentry, joinery, lathe-work, engine-testing, wiring, fabric sewing, painting, blacksmith's work, and a dozen other jobs had to be done, and done without paid help for the most part because there was no money to pay the labour with. Practically every repair had to be done in the ramshackle sheds with make-shift tools, and often enough the painstaking work of weeks was wrecked in a few seconds—wrecked before the new idea could be given a fair test, and all the slow, heartbreaking work had to be done over again. The unimaginative commercial man and manufacturer can be forgiven for his refusal to invest money in the aeroplane industry during the first few years of its existence.

After a while, and when the aeroplane was an established fact with a certain element of danger about it, numbers of wealthy amateur sportsmen were attracted, and the situation was somewhat eased in certain quarters, which then welcomed a few pounds and a few years later dealt in hundreds of thousands. At a later date, when business men could be shown the machines in actual flight, capital became rather less coy; Governments bought some few machines and placed orders for more . . ., and it is axiomatic that money for official contracts is more easily obtained than for such things as " making-a-flying-machine " or " jumping-over-the-moon," these things being thought to have much in common at the beginning of the century.

Some engineers realised early enough that powerful and reliable motors were really needed, and as most of these firms were already established, matters were speeded up by so much. Engine building was only part of the job, however, and while some of the early experimentalists started their own woodworking shops, mostly out of their profits as exhibition pilots, others drifted away from the building of the complete machines and began to specialise in such things as propellers, fuel tanks, and other things needed in aeroplane construction. So the industry which was destined to have a revolutionary effect on the world's progress came slowly into being. Always it was hoped that some day the Governments would wake up to the possibilities of aircraft and order the building of big air fleets—a move, incidentally, which would set the baby industry on its feet. The Governments had a ruder wakening than many bargained for, and when aeroplanes were needed, not in odd dozens but in thousands, there was room for thankfulness that aeroplane builders had refused to be crushed out of existence by official ineptitude and neglect. It then became possible to manufacture aeroplanes on a commercial basis.

The first essential in quantity manufacture is some degree of standardisation, and in this respect Germany had a big start over any other European Government. Already, when war broke out, there were practically only four engines being manufactured on any big scale in Germany: there was an air-cooled rotary, an improvement on the Gnome, the Benz and Mercedes water-cooled units, and the Maybach engines which had been developed side-by-side with the German airships. Other makers were experimenting, of course, but the Government, with its eye on current events and a plan of campaign pigeon-holed, had encouraged the quantity production of the units mentioned. When war was declared—even some time before it was declared—the order was full speed ahead with the standardised engines, and outside makers were ordered to stop work on their own designs and divert their workshop plant to helping in the manufacture of the officially-approved models.

France and England were in a different position, for all sorts of makers were building all sorts of engines, and as none had been fully and fairly tested it was necessary to give all an opportunity of showing what their productions could do. This led to delay that had its effect even in the fourth year of war. So far as aeroplanes went the position was that both the French and the British War Departments had numbers of officially-approved designs in addition to many machines from private builders. When the need became urgent, orders were placed wherever there was a chance of their being executed. It was quickly realised that the demand greatly exceeded the possible supply unless the available manufacturing facilities were extended. Private enterprise then proved of supreme value. Firms in all parts of the country were encouraged to tender for the making of parts, and although there was often enough that strangling of initiative by red tape, so common in all Government Departments, commonsense was also shown in the financial and other arrangements made.

That aircraft would prove the deciding factor in the war was not realised for some years; as a valuable auxiliary arm there was not dispute from the first, but when some of the Allied newspapers demanded that ten thousand aeroplanes should be built without delay and used to bomb German towns, the thing was said to be impossible. Many articles were also written to prove the impossibility of aeroplane manufacture on so large a scale; it was pointed out that aeroplanes needed engines, that there were only so many engine builders in the country, that their output was strictly limited, that it could not be greatly increased during the war, that the training of thousands of pilots was a long job, and that, in short, the job could not be done. War, however, is a stern teacher, and in its fourth year each belligerent Power was looking forward to the possession of an air fleet numbering hundreds of thousands of machines; the United States saw this so clearly that her first aircraft programme called for the building of over 22,500 machines, together with an adequate *personnel* and a completed auxiliary equipment.

Aeroplane factories began to spring up in Europe and America in magical fashion, and the romance of the work can only be written in the future, when the full story can be told without giving information to the enemy. Unimportant manufacturers of bone buttons and mouth-organs and a hundred and one other things soon found themselves employing thousands of peo-

AN AMERICAN HIGH-SPEED SCOUTING AEROPLANE, IN WHICH, BY CLEVER CONSTRUCTION, ALL OUTSIDE WIRES HAVE BEEN AVOIDED

A BRITISH NAVAL OBSERVATION BALLOON PREPARING TO ASCEND FROM ITS PARENT SHIP

A BRITISH NAVAL OBSERVATION BALLOON PREPARING TO ASCEND FROM ITS PARENT SHIP ple engaged in the production of aircraft parts; some men, starting practically without capital, built up organisations employing millions of capital in the space of months. One genius, who had had his natural shrewdness sharpened by American experience, started as an aeroplane manufacturer in the first year of the war with a capital of less than £100, and, two years afterwards, had a weekly pay-roll of over £8,000!

Many of the lighter industries, such as piano-making, for example, proved to be particularly suited to aeroplane manufacture; motor coach-builders were turned into propeller makers and woodworkers; french polishers were set to applying dope to the wings of the machines; and scores of other trades proved to have some special value. The most satisfactory thing of all was the way women adapted themselves to the work, and very soon literally tens of thousands were employed in the aircraft factories. They looked after the wood and metal-working machines; they glued and screwed and shaped the struts and spars and ribs; they sewed the fabric over the framework; they erected the minor accessories; and, a revolutionary performance, they proved competent acetylene welders—a job which, before the war, was said to be possible only to men of long training and experience in metal-working. The Ministry of Munitions arranged that free training should be given in the different English munition centres, and, in a few months, because it was not a case of artificial restriction on output, the women learned to do work that was supposed to take years in the case of men—incidentally dealing a deadly blow at the apprenticeship system in doing so. Wages, naturally, are higher for skilled than for unskilled work, and because so many women became skilled during the war it is more than probable that in the future the work will remain largely in their hands, for the aircraft industry can never again sink to an unimportant position.

So the old happy days of "make do" and "do it oneself" went sometime between 1914-16, for ever. Aeroplane building is now a coldly scientific job, where costs are calculated to decimal parts, times per operation recorded in small time fractions, the world searched for raw materials, and each individual part, each unimportant component, must, first individually and later collectively in the completed machine, undergo tests leaving no margin for carelessness in construction nor weakness in material. The work is now, notwithstanding that improvements follow each other hot foot and that a speed of 150 miles per hour to-day may seem a crawl next year, on the same commercial footing as the manufacture of motor-cars or any other standardised product in big demand.

It may be taken for granted that designers know practically all there is to know about what any machine can be expected to do. A case can be stated: certain aeroplanes were subject, under certain conditions, to develop a whirling or spinning nose-dive which caused the deaths of many fine pilots, until a British officer showed how it could be pulled out of. Nowadays no designer worth his salt would build such a machine, unless, for some other end, he resolved to risk the spinning tendency; in any case, he would be perfectly aware of what he was doing. By this much has knowledge increased. In war, however, certain risks must be taken, and it is not easy to build "fool-proof" machines without sacrifice of other things quite, and sometimes even more desirable, than fool-proofness. Apart from war the matter is different, for excessively high speed is unnecessary in the commercial aeroplane; but in the fighting scout it is the beginning and the end of all things. The problem fronting constructors in the future is not so much one of knowing how a machine will behave in the air, but how to obtain given results with the materials to hand, results, that is, making an advance on existing practice.

Every aeroplane is designed to fly best at a certain speed and height. If at 120 miles an hour the supporting surfaces are doing most work, it follows that at 60 miles an hour the machine is approximately only 50 per cent. efficient, and at 30 miles an hour the speed would be insufficient to support flight; the designer has to build an aeroplane that will fly best at a high speed and yet support itself in the air at a very much lower speed in order that the pilot may make a landing. A very expert pilot can, as a matter of fact, make a landing at 80 miles an hour, especially when he has a big aerodrome to alight in, and also, because to those that have, all things are given, the expert pilot can, with most machines, land at a very much lower speed than an average pilot. He can judge distances so accurately that within a very few feet of the ground his flight changes from slightly downwards to the horizontal, the tail of the machine is dropped, very gently, until contact with the ground is established. The wings are then pulled up to the air . . . and the pilot climbs out and asks for a "gasper." These things are not given to the average airman who, for safety's sake, demands an aeroplane able to fly at 100 miles an hour top speed and as low as 20-30 miles an hour for landing purposes. Speed and slowness, however, make a poor blending, but the problem is not impossible and something very near to it can be done even to-day.

Many improvements are still to come and very probably in the future it will be possible to vary the wingspread. Were something of this sort done there would be for top flying speed a very small wing area, and for landing a greatly increased surface to so enable flight to be supported at a very much lower speed. There need to be telescopic wings under the pilot's control, and the all-metal aeroplane seems absolutely essential for this sort of construction; alternatively, wood reinforced by metal may be used. In addition, more trustworthy and positive brakes will be fitted to check the speed of the machine on the ground just as a car's speed is checked. As an illustration of what can be done by simple alterations in design, one of the favourite fighting machines used by British pilots in 1917 had, when fitted with an 80 h.p. engine, an alighting speed of something very near 75 miles per hour. The 1918 machines were fitted with 180 h.p. engines, and, although the top flying speed was greatly increased, the landing speed, because of small alterations in the wings and side surfaces, was brought down to nearly 60 miles per hour. There is an immense scope for clever design, and those who believe that the aeroplane has reached finality or anything like it will have some very staggering surprises within a remarkably short time of the war's ending.

Although aeroplane parts in wood were standardised so far as was possible, the authorities in every country were faced with the difficulty that many thousands of spares were needed because of the different types of machine flown. In war these things seem inevitable. In the future the makers will concentrate on well-defined types of machines for given work, and, although the purchaser will have the choice of a number of different makes, he will find, because manufacture in general tends to become more and more scientific, that standardisation has been carried much further than ever before and, apart from those sections in his machine which are essentially the maker's own patents, the part that will fit the "B" touring 'plane will prove equally suitable for the "C" tourer. It will be this need of extreme standardisation, together with the growing difficulty of finding enough suitable wood for the world's needs, that will tell very heavily in favour of the all-metal machine. Aircraft for war purposes are not long lived, and because it is easier to produce special wood-working machinery than to erect new works for special metal rolling and bending purposes, wood has been extensively used in the wartime machines. There is no good reason why propellers should not be standardised, and although there will be no restriction of choice, variable pitch propellers will also make their appearance. As to engine standardisation, it is difficult to lay down any hard and fast rule.

One of the greatest problems facing the engine builder is the building of a motor able to develop full power continuously and for long periods without wearing out and breaking down. If every working part could be given a diamond-hard surface and temperatures were equitable and constant, the job would be comparatively simple. These things, alas! are not, and as the aeroplane calls for both power and lightness in its engine, the combination can only be given with high speed. A simple multiplication sum gives the number of revolutions travelled by an engine running at 1,000 revolutions per minute during a six-hours' flight, but if the engine could be run at one-quarter the speed it would, other things being equal, last four times as long without breakdown. The majority of the machines in use in 1917 had the propeller geared direct to the engine, and because of this either the one or the other was not so efficient as could be desired. Obviously the solution consists in fitting a gearbox just as in car practice—an unscientific production which by all the rules and portents ought to smash itself up in a remarkably short time, but which, in point of fact, works extremely well. Worked in combination with a variable pitch propeller the gearbox would allow the pilot a range in power and speed, and it would be possible to "nurse" the engine to such an extent that the life of the whole machine would be increased and considerable fuel economy made.

A further and most important point is the prevention of engine failure immediately after leaving the ground. At a height of over a thousand feet the matter is not so serious, for the nose of the machine can be put down and forward changed into a gliding flight, the pilot's chief anxiety being the selection of a convenient landing ground within the limit of the glide. Engine failure between ten and a hundred feet means, in ninety-nine cases out of a hundred, a bad crash, for the machine, its forward and upward flight checked, drops like a stone. The difficulty can be overcome by installing two or more engines each powerful enough to maintain forward flight unaided. Aeroplanes so fitted proved very successful during the war, cases being known where one of the units was struck and wrecked by enemy fire without the aeroplane's being affected to an extent which made it impossible for the pilot to reach the safety of his own lines.

To make doubly sure two or more propellers would also be necessary, for even if half-a-dozen engines were fitted, all driving the one propeller, the risk of smash within a few feet would still remain. The gearbox may be "chewed up," the propeller-shaft fracture, or the propeller itself splinter and break. Duplication of parts undoubtedly minimises risk most, but the steering gear on a motor-car is not duplicated, although fracture when the car is travelling at high speeds means almost certain disaster. The truth of the matter is that makers have had so much experience that the required strength to withstand every strain likely to be imposed, apart from accident, is understood to a fine degree, and a big safety margin is allowed. Much the same result will be reached in course of time with the aeroplane.

The dangers of flying have always been overemphasised because everything that is new and of general interest is treated of in the Press. To climb thousands of feet in the air has never been considered an everyday possibility by the ordinary citizen, who imagines such a procedure to be fraught with disaster. He, good easy man, knows that a fall of 10,000 feet means death, and considers flying dangerous: yet he will trust himself in railway trains and ocean steamships with never a thought of the potential danger. The pioneers were brave, extraordinarily brave, because they faced unknown perils, but present-day flying calls for no more bravery or personal risk than driving a motor-car, travelling in a railway train, or crossing the ocean in a liner. War flying is much more dangerous than flying in peace-time and yet statistics show that other branches of the Services are distinctly more dangerous. Mining, infantry and artillery each have a higher percentage of casualties than the aeroplane. Compared with motor-cars the percentage of deaths per thousand miles covered during the first few years of car-driving and flying respectively are lower in the case of the latter. The statement may be hard of credence; it is solemn fact, nevertheless.

Improved construction and greater knowledge of safety factors and design, coupled with the use of better materials, have all reduced the risks of flight. During the war the Governments of the Great Powers lavished money in research work, partly because better materials were urgently needed, and partly because each country found itself short of materials for which it had previously relied on enemy sources. Chemists and metallurgists were supplied with abundant funds and given a free hand, and they crammed fifty years' progress into three and produced both better materials and improved methods of production. So successful were their efforts that products which in 1914 could only be used sparingly and for special purposes because of high cost and limited production were, three years later, being used extensively, both aeroplane and engine builders coming in for direct benefit.

For future use aeroplanes must be of great weight-carrying and flight capacity, and already engines capable of running a hundred and more hours under full load are available. At a reasonable flying speed such a performance is equal to 10,000 miles. After cleaning and adjustment the units are capable of repeating the task, and although the time comes when so much wear has taken place that the engine must be scrapped, the same thing happens to motor-car engines and locomotives, and is not held to their discredit. After 100,000 miles of running the car owner can, without feeling that he has made a bad investment, scrap his car. In America he is encouraged to do so because, although the machine is capable of further work, it has become, either by wear or the improvement of other cars, uneconomical. Modern manufacture dictates that it is cheaper and more scientific to build new cars than to patch up old ones, and what applies to motor-cars will, to a great extent, equally apply to aircraft. When the machines have done service sufficient to cover their first and upkeep costs, and have paid a dividend in addition, they will be scrapped; there will be no attempt to build flying machines to last for ever or even for a life-time.

Aeroplane engines are now as long lived and reliable as car engines, bearing in mind the difference in the class of work done. The units for war service are exceptional and have no more relation to the aeroplane proper than has the high-speed racing car engine to its more plebeian brother in the touring car or motor truck; none the less, the experience gained in building aircraft for war will be of great value just as is the experience gained on the racing track or in the great International car races.

Apart from the question of flying and landing speed already treated of, a limit is reached when wing surface will support no further weight, and if more must be carried bigger supporting surfaces must be provided. This can be done in three ways. Present designs can be adhered to and the wing surface extended; the number of wings can be increased; or both suggestions can be incorporated in the one machine. Considering the first idea: it is not an impossibility to have wings one hundred yards long, but the mechanical difficulties are so many and varied that at present it is impractical. There would be the problem of housing the monster, of providing sufficiently powerful engines, of staying, strutting, wiring and reducing head resistance, of designing control gear strong yet delicate enough for the pilot to handle, and other incidental matters. Nor can the number of wings be added to indefinitely. The Wrights used a biplane in 1909 which supported 2.05 lbs. per square foot. M. Blériot, who believed in mechanical simplicity and who had not the experience of other constructors to guide him, believed in the monoplane, and his cross-Channel machine carried a load of 4.5 lbs. per square foot. Modern machines carry loads very much greater than either of these, and in addition, constructional methods and materials are vastly improved. Greater knowledge of design has made it possible to reduce the exposed surface to a minimum, and in 1917 triplanes were being built which had practically no external wires, and wind resistance, by careful streamlining, had been very greatly reduced. These machines achieved tremendous speed and probably indicated the lines along which the aeroplanes of the future will be constructed. Greater sup-[illegible]ting sur[illegible] be given by fitting extra [illegible]—an old idea revived, experience now having shown how each wing may be set to do its full share of work—and by having each wing, or possibly the main planes only, telescopic. The main planes, and possibly the tail, will fold up for convenience in housing. Head resistance will be reduced by streamlining and by fitting under-carriages which when the machine is in flight will telescope into the body of the aeroplane. The question of increased engine power may safely be left to the engineers who have doubled and trebled the capacity of their power plants in rather less than three years.

From the foregoing it may seem that the improvements written of are matters for the future with quite an element of doubt as to whether some will materialise at all, but such an impression would be entirely wrong. In point of fact, much has already been accomplished. Indeed, but for the difficulty of writing about definite machines without giving offence to the authorities, this text could be illustrated by machines actually in existence.

A final word may be said about the construction of the aeroplane in the modern way or, if the reader prefer it, the modern aeroplane. In the future the machines will be standardised and built in much the same way as motor-cars or any other engineering product in great demand. Orders for the individual components will be given out to the respective shops; from the stores will be taken the finished parts for building the complete unit; there will be the final testing and painting; and . . . the public will apply for the maker's catalogue and go home to discuss with the feminine members of the family whether the new machine shall be a fast two-seater or a comfortable and slower "family" 'bus which will take the children and the luggage. As with motor-cars the ladies will decide the appearance and colour; the men will be left to choose engine power and to write out the cheques.

# ENGINES

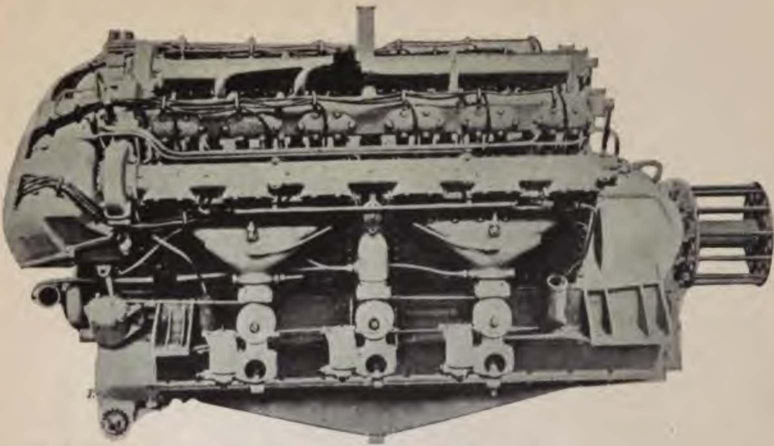
# CHAPTER VIII

## ENGINES

THE importance of the engine to the aeroplane has been repeatedly discussed, and it is not going too far to state that had satisfactory engines been available sooner the practical flying machine would have made its appearance at a considerably earlier date. The main principles of mechanical flight were known and to an extent understood a century and more ago. Sir George Cayley, for example, outlined a plan which some decades later, in 1843, was carried into effect in a model built by later investigators. This model had a total of 80 square feet of supporting surface, it had two propellers, flexible wings and tail for controlling movement in the air actuated by pulleys and cords, covering fabric was laid over the structure as in modern practice, a central mast for staying the wings was fitted, and wheels were provided for the preliminary movement over the ground while the machine was gathering its flying speed. Altogether the model was startlingly like many later aeroplanes. Calculations showed that a fullsized aeroplane to these designs would need in all 10,500 square feet of supporting surface, which, at a load of ½ lb. to the square foot, would carry well over 5,000 lbs. dead weight; the 25 h.p. steam engine which was to be used, together with fuel and passenger, would make the full weight of the loaded aeroplane up to 3,000 lbs., leaving a margin in hand for profit earning!

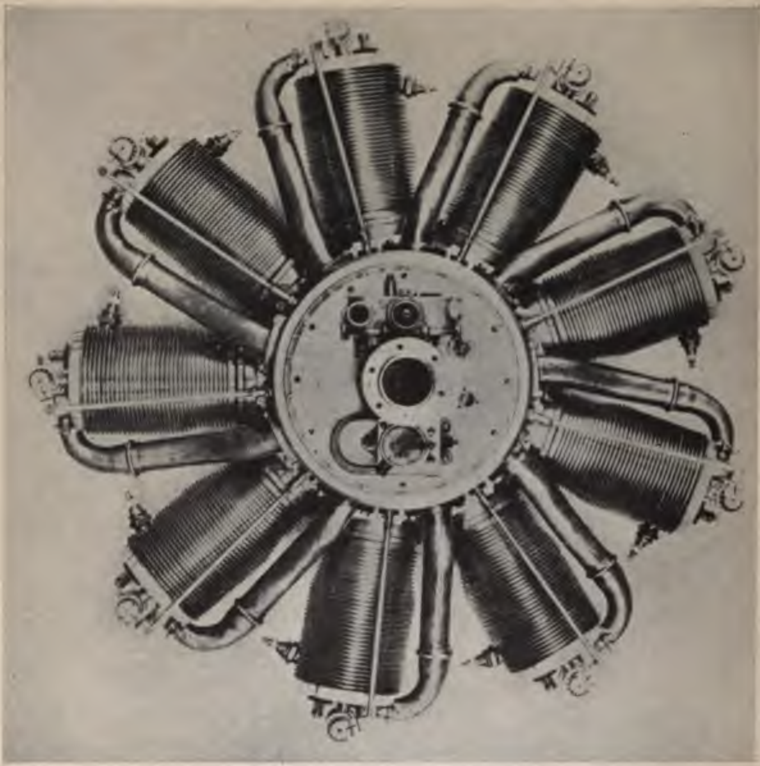
In 1902 Professor Langley, an American scientist, built a machine which it pleased him to call an "aerodrome," and which was very similar in appearance to the early machines successfully flown by other makers. No actual flights were made with it, however, until Mr. G. H. Curtiss, the well-known American aircraft constructor, rescued the machine from the museum it was housed in, thirteen years later, and made successful flights without finding need for any radical alteration in the design. The late Sir Hiram Maxim also built a steam-driven aeroplane which developed appreciable lifting powers. From these and other facts it follows that no real progress could be made until suitable engines were available. At last this state of affairs was reached.

The development of the internal-combustion engine will be recognised by future generations as one of the most important steps in the world's



THE 18-CYLINDER WATER-COOLED SUNBEAM-COATALEN AIRCRAFT ENGINE OF 475 HORSE POWER

AN AMERICAN SEAPLANE RETURNING TO ITS MOTHER-SHIP



AN INSTRUCTIVE VIEW OF A ROTARY AIR-COOLED AEROPLANE ENGINE progress, for it made possible both the motor-car and the aeroplane. It had many advantages over other power units. Power and lightness were combined in it, trustworthiness was simply a matter of time and mechanical improvement, it was compact, and there seemed no good reason why it should not be capable of almost infinite development. Although there were many difficult problems to be overcome and progress seemed slow at times, improvements were in reality made almost at lightning speed. In a year or so the little single-cylindered air-cooled engines rated as of 3 or 4 h.p. had given place to the two-cylindered water-cooled unit, and this in its turn to the four- and six-cylindered affairs—allowing for occasional delvings into three cylinders and curious groupings—which have themselves of late been rivalled by the eight- and twelve-cylindered units. Continuously the trend has been towards lightness, trustworthiness, fuel and oil economy, and greater power. The perfecting of magneto ignition was a great step forward; in its way and its day it was as important as the engine itself. Germany, realising this to the full, made a great effort to capture what was considered to be a "key" industry, and like so many of her other plans this one also nearly succeeded. But again Germany failed in not giving credit for sufficient intelligence to her enemies.

The U.S.A., naturally independent, had no liking for buying German magnetos, and her engineers had succeeded in building parts equally as reliable as those originating in Europe; in addition they had developed a battery system which on the outbreak of war was beginning to rival the magneto. What Britain and France lost from Germany they made good from America.

The Wrights used an adapted four-cylindered car engine in their first practical aeroplane. Lightness they knew to be an important consideration, but power and trustworthiness were thought to be more important still. Other engines were soon being used in Europe but they were all adaptations in some form or other of the car engine. The first rotary engine which was a Gnôme marked the most important step in the progress of the aeroplane since the Wrights first flew at Dayton. It was designed primarily with a view to its use in flying machines, and it at once doubled the power available and halved the weight. Naturally it was not perfect. Its extravagance in lubricating oil made it almost impossible for the thriftily inclined to consider flying as a business; the valve arrangements were so unmechanical that engineers said the engine would not run at all, and when actually confronted with it in operation declared that they didn't believe it! Fuel was fed to the cylinders through a hollow crank-shaft and the crank-chamber, and the connecting-rods were all geared to one crank-pin through a main connecting-rod. The exhaust valves were located centrally in the cylinder heads, and with forced lubrication and the revolving mass of the cylinders whirling round at over 1,000 revolutions per minute, it is not difficult to understand where a big percentage of the lubricating oil went to. The original Gnôme engines also presented economic difficulties in the matter of fuel, for, owing to the automatic inlet valves, any throttle control was in effect impossible, and the engine ran always at top speed.

Improvements were effected by admitting the gas to the combustion chamber through slots in the skirts of the cylinders and by fitting mechanically operated valves. Naturally it was not long before other concerns took this type of engine in hand and, so they claimed, improved it. This is no place to side with either a yea or nay: let it be sufficient that when war came both the original inventors and makers and their more or less friendly rivals and competitors went on making engines for Hun-strafing purposes, and did it very well. Coincidentally with the development of the rotary engine other makers were giving attention to engines of quite another type—the vertical and V-shaped water-cooled units, and by 1914 very remarkable and gratifying results had been achieved.

When war broke out Germany had at least three works of considerable output capacity turning out well-proved vertical engines and other establishments making the rotary units under licence from the original patentees. France had dozens of makers of both good and bad engines. England was in much the same position as her Ally, with the difference that the British Government had never been able to see any virtue in any British production. In direct consequence when war broke out not a single aero or seaplane belonging to the British Government had a British-built engine in it! A remarkable record was then set up. One of the most successful French engines was dismantled, measured to the last detail, drawings and patterns were put in hand, and seven weeks after the start the completed unit was on the test bench. It was easier at that time to build engines than magnetos, and it was the United States that saved the situation until such time as British makers could get hold of it, which after a time they did so well that it is more than likely Germany lost for ever an industry worth millions of pounds per annum.

No startlingly new departures were made in engine construction under the stress of war, unless, of course, acceleration in output from nothing in one year to something like 1,000 engines per week in three years or the doubling and trebling of the horse-power be regarded as startling. Germany went along steadily, keeping to her standardised units, which underwent steady improvement during the war, and because of her carefully set policy doing wonders in keeping step with the combined resources of the Allies—for a while. France built rotaries and a few big-powered V-type engines. Italy put out some very excellent units, mostly in the vertical and V-type classes, and England began to make one or two splendid engines of native design, such as the 250 h.p. six-cylindered Rolls-Royce, the 6-, 12- and 18-cylindered Sunbeams, and the B.H.P. unit, built by the Galloway Engineering Co. The "Raf" engines—*Anglice,* the designs of the Royal Aircraft Factory of unhappy memories—were built by many different engineering concerns throughout the country, and other makers were encouraged to build engines of approved design. Although writing almost on the heels of the event, it would be inadmissible, when writing of aero engines and their production in war-time, to omit reference to the American "Liberty" unit, which has created many world's records and which very possibly will prove the deciding factor in the war. The United States Secretary for War is the most competent to speak of this particular unit and its making. He says:—

"I regard the invention and rapid development of this engine as one of the really big accomplishments of the United States since its entry in the war. The engine was brought about through the co-operation of more than a score of engineers, who pooled their skill and trade secrets in the war emergency. . . .

"One of the first problems which confronted the War Department and the Aircraft Production Board after the declaration of hostilities was to produce quickly a dependable aviation motor. Two courses were open. One was to encourage manufacturers to develop their own types; the other to bring the best of all types together and develop a standard. The necessity for speed and quantity of production resulted in a choice of the latter course, and a standard motor became our engineering objective.

"Two of the best engineers in the country, who had never before seen each other, were brought together at Washington, and the problem of producing an all-American engine, at the earliest possible moment, was presented to them. . . . For five days neither man left the suite of rooms engaged for them. Consulting engineers and draughtsmen from various sections of the country were brought to Washington to assist them. The work in the draughting room proceeded continuously, day and night. Each of the two engineers in immediate charge of motor development alternately worked a 24-hour shift.

" An inspiring feature of this work was the aid rendered by consulting engineers and motor manufacturers, who gave up their trade secrets under the emergency of war needs. Realising that the new design would be a Government design, and no firm or individual would reap selfish benefit because of its making, the motor manufacturers, nevertheless, patriotically revealed their trade secrets, and made available trade processes of great commercial value. These industries have also contributed the services of approximately 200 of their best draughtsmen. . . .

" A remarkable American engine was actually produced three weeks before any model could have been brought from Europe. It was promised that this engine would be developed before July 4th. Twenty-eight days after the drawings were started the new engine was set up. This was on July 3rd. In order to have the engine in Washington, and in actual running order at the nation's capital on Independence Day, the perfected engine was sent from a Western city in a special express car. . . .

"Parts of the first engine were turned out at twelve different factories, located all the way from Connecticut to California. When the parts were assembled the adjustment was perfect, and the performance of the engine was wonderfully gratifying. Thirty days after the assembling of the first engine, preliminary tests justified the Government in formally accepting the engine as the best produced in any country.

"While it is not deemed expedient to discuss in detail the performances and mechanics of the new motor, it may be said that standardisation is a chief factor in the development of the Government's motor. Cylinders, pistons and every other part of the motor have been standardised. They may be produced rapidly and economically by a great many factories operating under Government contracts. They may be as rapidly assembled, either by these plants or at a central assembly plant. The new engine amounts practically to an international model. It embodies the best there is in American engineering, and the best features of European models, so far as it has been possible to adapt the latter to American manufacturing methods. . . .

"The standardisation of parts materially simplifies the problem of repair and maintenance. Spare parts will be promptly available at all times. Even the cylinders are designed separately. It is possible to build the new engine in four models, ranging from four to twelve cylinders, and under the standardisation plan now worked out an eight-cylinder or a twelve-cylinder model can be made, using the same standard cylinders, pistons, valves, cam shafts, and so on. This will make the question of repairs a comparatively simple matter. The parts of wrecked eight-cylinder or twelve-cylinder engines will be interchangeable, and a new engine may be assembled from the parts of wrecked machines.

"The standardisation of the new engine does not mean there will be no change in it during the war. There will be continuous experimentation, as new types and improvements develop at the front, and new ideas are born of the war emergency. If the engine can be improved, it will be improved; but as the motor stands to-day it is one of wonderful success, and produced under dramatic circumstances. Construction of the new standard engine will not interfere with the continued manufacture of other serviceable models, either European or American, which existing plants are already turning out. The production of the United States motor will be carried on almost entirely in a new and expanding industrial field.

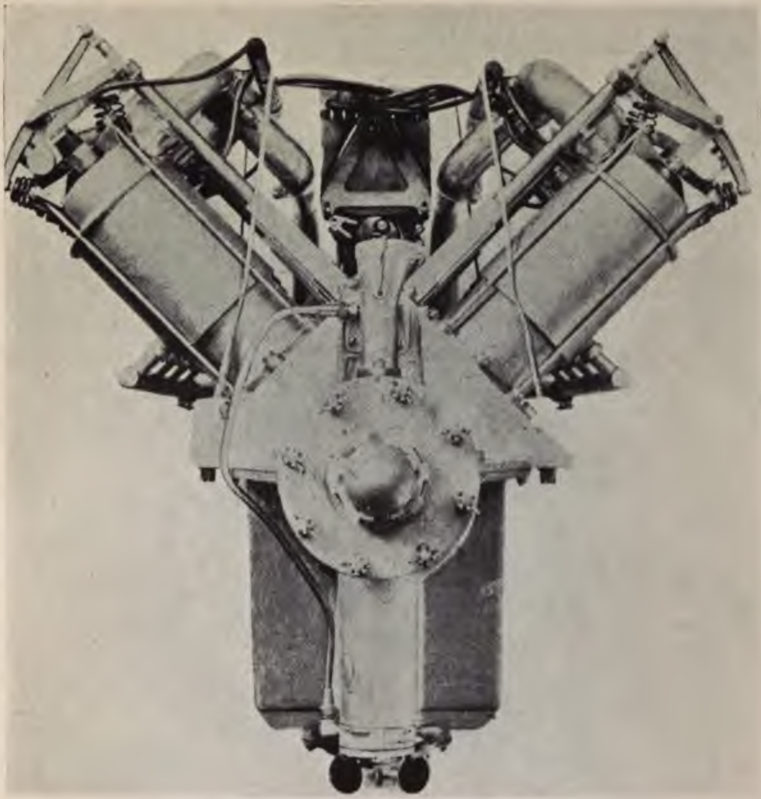
"The Government is sometimes asked, 'Why does not the United States adopt one of the successful British or French high-powered machines and manufacture them?' British and French machines, as a rule, are not adapted to American manufacturing methods. They are highly specialised machines, requiring much handwork from mechanics who are, in fact, artisans. It would require a year or more to teach American manufacturers and their mechanics to turn out such high-specialised aeroplanes."

Few things proved more embarrassing to the Allies than the many different aero engines they were called on to use. England had, as near as makes no matter, about forty different engines in use, and France nearly fifty. There was no fault to be found with the performance of the majority; the trouble consisted in the supply of spare parts and in the delay in production inevitable when so many firms, in addition to building new engines, had to give part of their workshops over to the making of spares in order to keep their own machines in the air. In many cases not even magneto housings or propeller couplings were interchangeable.

Although experts of many kinds have suffered in reputation during the war there were some, a very few, who greatly increased whatever reputation they held in 1914. Among these are the more prominent designers of aero engines who, being asked simply to give of their best without regard to time, season or the work of rivals, did work that, in ordinary times, would have set the world by the ears. Therefore, as a summing up to this chapter on aircraft engines, it is proposed to give the views of Mr. Louis Coatalen, chief engineer and designer of the Sunbeam Motor Car Company, who designed the famous Sunbeam-Coatalen engines which are now being manufactured under licence in America by the Stirling Engine Company, of Buffalo, N. Y.

Mr. Coatalen makes the following points, amongst others, in regard to aero engines. Weight is of prime importance. Cost is not the deciding factor provided the necessary amount of power is obtained for the given overall dimensions of the engine, for its weight both as regards material and fuel, water and lubricant consumption; and that the desired degree of reliability is obtained. The amount of labour necessary to produce a satisfactory aircraft engine of high output is, and will be, always many times what is necessary in the case of a car engine, and is a matter of secondary importance provided the desired results are obtained. No machining is too expensive if it saves weight. Silence is relatively unimportant. The aircraft engine does all its work at practically full power. Flexibility is of very secondary importance.

The aircraft engine of to-day is not akin to the standard motor-car one. Admittedly, the twain are collaterals, both deriving from a common stock, the four-stroke cycle, petrol internal combustion engine. For the rest, the aircraft engine of to-day is, perhaps, as little like the standard motor-car one as that resembles the variety used on a commercial motor vehicle or that installed in a motor-boat. By contrast, there is another type of engine specially built, which has much in common with the aero engine. In the unit of racing motor-cars: Weight is of importance. Cost is unimportant. The amount of labour and the time necessary for production are matters of relative indifference provided the maximum output of horse-power is obtained for a given size of engine. That demand has led manufacturers to employ overhead valves, which are also used in aviation service, and which so far have been employed comparatively little in standard car practice, partly on account of the principle not being so quiet in operation as the side-valve system. Every part of a racing car engine must be machined. The connecting rods are



A REPRESENTATIVE AMERICAN AIRCRAFT ENGINE

milled to the minimum section, and so forth. Silence is of no importance whatever. The racing car engine does all its work at practically full power, but the evenness of its torque has to be extended over very much wider ranges of speed than is needed so far in the case of an aircraft engine. From 1,600 to 3,400 crank-shaft revolutions a minute is called for in the former case, whereas in the latter the normal speed is 2,100. The last-named figure chances to be no less than 1,300 revolutions a minute slower than the capacity of Sunbeam racing car engines. Therefore it will be appreciated that the engine for racing car service is submitted to bigger stresses than the present-day aviation engine; but that this period of high stress in the case of the vehicle variety is much shorter than obtains in that of the aviation type unless, indeed, the car is being run on a track. Even in that event twelve consecutive hours is considered a very long spell, whereas in aircraft service that period of uninterrupted power output is held to be all in the day's work. The racing car engine resembles the aviation type in that a very high mean effective pressure has to be obtained with both. In some racing car engines it has amounted to 135 lbs. to the square inch, taken from the brake horse-power developed at the flywheel. As the problem is power for engine weight and volume, and not silence and low cost, great freedom is allowed the racing car engine designer as regards piston clearances, valve timing, compression, largeness of valve area, strength of valve springs, and so forth, the opportunities in this connection approximating much more to aviation than to standard car engine practice. Comparatively large horse-power is needed in the case of all engines for racing cars, the average being anything from 80 to 225 h.p.

To approach the problem from the correct point of view, says Mr. Coatalen, we must recognise that the outstanding desiderata in designing aircraft engines to-day may be summarised thus:—

(*a*) Light weight, combined with low fuel and oil consumption, per horse-power.

(*b*) Reliability.

If we can but attain those characteristics with units of not less than, say, 200 h.p.—better still, if we can exploit them in units each up to 600 h.p.—then we can afford more or less to neglect other desiderata as being of minor importance. Nevertheless, happily, we can already go a fair way towards realising what we might style the minor desiderata which at this period of the war include:—

(*a*) Simplification to the utmost in face of these engines being placed, for the most part, in the hands of a great number of men semi-skilled in even flying and maintaining them.

(*b*) Fool-proof as much as possible in that some of the most daring Service fliers have not either the temperament or the understanding to spare the engines of which they are put in charge.

(*c*) Accessibility in face of the frequent attention needed by all aircraft engines and of the fortunes of war rendering it necessary on occasion to replace the most vital parts.

(*d*) Standardisation because for the first time in the story of motor engineering we are making engines of high output in series in place of about a half-dozen examples at a time.

(*e*) Suitability of exterior form that the power plant may be accommodated conveniently in the aircraft and occasion the minimum displacement.

Thus there are strict limits to the diametrical size of radial engines, whether of the rotary or of the stationary type, which it is profitable to employ for aircraft work; while in regard to the vertical, or to the V-type engines, the nature of the particular service to which each individual engine is to be put likewise imposes certain limits. In certain cases strict limits must be set to overall length of the engine, particularly at a time of war in the air, when, at need, it is essential to lose the minimum time in altering the flight path of the machine from a diving attitude to a very steep climbing one. Again, some sorts of aircraft call for the minimum engine head resistance, but are less imperative as to overall length; hence the six-cylinder type would be suitable for such service, whereas the V-type variety would not be.

In regard to the general arrangement of aircraft engines, there are several main types, each of which involves advantages as well as disadvantages. The business of the designer is to effect the best compromise possible to fulfil the particular class of service that is had in mind in scheming the individual engine.

Of course, multi-cylinders are common to all types of aircraft engines. But the arrangement of the cylinder groupings and settings differs entirely as between one type and another. Doubtless the most generally favoured form is the V type with either twelve or eight cylinders per unit, these being set in two rows on a common crank-case whereby one crank-shaft suffices because one crank-pin serves for each pair of opposed cylinders.

Undoubtedly next in order of importance is the radial type, in which the cylinders are set in one or more planes with axes radiating from the centre line of the crank-shaft.

The two sub-divisions of the radial type of engine are the rotating and the fixed variety.

What we may style the straight-line engine constitutes the third main type. In this four, more generally six, and, in a few examples, even eight cylinders, or twelve, are placed in a line and are set vertically on a crank-case, the pistons and connecting rods acting as a crank-shaft with one crank-pin per cylinder in the orthodox fashion of motor-car engine practice.

Inasmuch as each of these three types has advantages peculiar to itself, it follows that each is the most suitable so far available for some particular form of aircraft. For instance, the cross-section or wind resistance area per horse-power is least in the straight-line engine and most in the rotating radial type. This includes the loss of power necessary to rotate the engine. The fore and aft length of the engine, however, which is of great importance in some aircraft, is least per horse-power in the case of the rotating radial type and greatest per horse-power in the straight-line engine. Moreover, when the straight-line engine is water-cooled, as is generally the case, the rotating radial type gains a further advantage on the score of decreased weight per horse-power. Against this, however, the economy of fuel and oil consumption which can be obtained with the straight-line water-cooled engine is appreciably greater than is possible with the rotating air-cooled type as designed to-day.

Somewhere between the two contrasted types of engines as regards the problems of wind resistance and overall length is what is styled the V type of motor, wherein weight per horse-power is lighter than in the straight-line engine, owing, of course, to the proportionately much greater crank-shaft size in relation to the number of cylinders employed. But if we consider the case of the air-cooled V-type engine, under the score of weight per horse-power, of course, it has to yield place to the rotating radial type.

Yet another type which I have produced and standardised during 1917 with highly satisfactory results is a development of the V form of engine in which more than two rows of cylinders are placed on a common crank-case. The particular engine had in mind employs three rows, each of six cylinders, on a common crank-case, each crank-pin being connected to three pistons by articulated rods. In this 18-cylinder unit the centre lines of the cylinder make, in relation each to the other, an angle of 40 degrees. This allows of a very good firing diagram. This type of engine is one that is considered very promising for units of very large power. As regards weight per horse-power, it has advantages over both the V and the straight-line types of engines.

With regard to the question of weight, the purpose for which the particular aircraft is required is of prime importance. Obviously, in the case of the engine in a machine designed for short flights only, the consumption of fuel and of lubricant is of less importance than the weight of the engine itself, whereas in the case of the heavier sorts of aircraft with which flights of long duration are obtained and for which great power per engine is needed, the consumption assumes much more importance than the actual weight of the engine. In these latter cases efficiency as regards the weight of the power unit has to be arrived at by taking the weight of the engine complete with the amount of fuel and oil that would be consumed in the course of a flight of, say, five or six hours' duration. Thus for short flights the rotary type of engine generally and the air-cooled varieties are apt to show up to advantage, though in them consumption may be comparatively high, because this is offset by the relative lightness of their starting weight. To my knowledge, says Mr. Coatalen, in the brief period of two years there has been obtained with this type a reduction in weight from 4.3 lbs. per h.p. to 2.6 lbs. per h.p.

As applied to aircraft engines, the proposition of carburation stands to-day somewhat on a basis of compromise. For this reason experiments now being carried out are directed towards obtaining more efficient and economical carburation. The tests made on Sunbeam-Coatalen aircraft engines at the manufacturers' works at Wolverhampton have shown a petrol consumption of .52 pint per h.p. per hour, coupled with an oil consumption of .022 pint per h.p. per hour. It will be readily agreed that this stands for a distinct advance on consumption by engines using ordinary type carburetters so recently as at the beginning of the war.

When this war began there was relatively little fighting in the air, and the average flying was done at anything from 4,000 feet to 6,000 feet. To-day our airmen rarely go over the lines at less than 16,000 feet, and fighting has taken place certainly at altitudes of 21,000 and 22,000 feet. Accordingly, it will be realised that at the outset of the campaign the problem of altitude was not thrust to such an extent on the attention of the designer and the manufacturer because such modest heights were deemed sufficient for aerial reconnaissance and other work, whereas in the interval it has become imperative to navigate the air at such vastly increased heights that the difference in atmospheric pressure can be ignored no longer, for the sufficient reason that the altitudes in question could neither be attained nor maintained if the problems presented had not been solved, at least in part, already. They concern both carburation and engine compression, as well as the matter of cooling. As to carburation, the influence of altitude is quite the most important matter now engaging the attention of designers.

Assuredly it is interesting to compare present-day achievement with results of, say, three years ago, as instance those obtained at the Naval and Military Aeroplane Engine Competition in 1914. As a result, it will be found that then the use of aluminium was practically confined to the crank-case only. Its application to the construction of pistons and other small parts of the aircraft engine was not known. Further, we find that the maximum mean effective pressure was approximately 106.5 lbs. per square inch, and that the average fuel consumption was .6 pint per h.p. per hour. The weight of the engine with fuel for a run of six hours' duration varied from 9.55 in the case of the rotary air-cooled variety to 11.27 in that of the vertical water-cooled type.

By contrast, to-day the mean effective pressure standardised has been increased to 135 lbs. per square inch, measured from the brake horse-power and, in some cases, actually through the reduction gear. At the same time fuel consumption has been reduced to .52 pint per h.p. per hour, while the weight of the V-type water-cooled engine has been brought down to 6 lbs. per h.p. per hour with fuel and oil for a six-hours' effort, all of which Mr. Coatalen holds to represent a notable rate of progress achieved in the brief period of less than three years.

As regards the heart of the aeroplane, its power plant, there is no sound reason for adhering to the general attitude of the British public, which is to decry home achievement, praise all foreign endeavour and, notably, to set German effort on a pedestal as something unapproachable. How erroneous is that idea when applied to the aircraft engine proposition you may gather from a single instance. Take the latest 6-cylinder water-cooled German Mercedes aircraft engine of the four valves per cylinder type. Without radiator and water that weighs 3½ lbs. per h.p. Now in this country there are designed and produced water-cooled engines which, without water and radiator, weigh 2.6 lbs. per h.p., nearly 1 lb. per h.p. lighter than the best known German performance.

# ACCESSORIES

## CHAPTER IX

### ACCESSORIES

THE day of great public interest in accessories is not yet. It will come when aircraft is as much part of the public life as the present big parcel delivery concerns; when there is a choice of aircraft for the same purpose and, more than anything else, when the makers, in their desire to attract attention to their productions by advertising a nice, round attractive figure without cutting too deeply into profit, begin to sell " bare chassis and wings." Then, indeed, will users rise in their wrath and hie them to the nearest accessory dealer, there to be sold a round dozen articles of greater nattiness than serviceability, while on their departure the dealer will dictate urgent letters demanding new " lines " from manufacturers to stenographers whose dreams are ever of the old happy days of inflated salaries and never-ending afternoon teas in Government employ before a disastrous peace broke out! What sort of accessories will be needed? Certainly there will be demands for improved shock absorbers for landing purposes to begin with. It may be argued that the makers of the aeroplanes will see to such matters. They don't and won't, at least not for many years, as witness motor-car springing to-day, which, to be really satisfactory, needs to be fitted with absorbers and grease-retaining gaiters. So that there will be needed all kinds of signalling appliances, lamps and so forth; indicators by the dozen for the convenience and knowledge of pilots and passengers; heating appliances, safety belts, parachutes, map-holders, ventilators and gear of many descriptions. Many years hence a time will come, however, just as it has with cars, when no very special impedimenta will be needed beyond those fitted as standard. In the meantime pilots will need tachometers for indicating engine speed, oil and petrol pressure gauges and other gauges to show the petrol level in the tank, aneroid barometer, compass (special aviation type, an unusually ingenious instrument), gradometer to show the angle of inclination in flight, air speed indicator, drift metres, lee-way and petrol flow indicators.

Ten years ago the motorist needed a special leather or fur coat when driving, simply because his car was not fitted with a wind screen. Nowadays the average man, whether he be driving himself in an open car or travelling with his chauffeur, steps into the vehicle in everyday attire and has no thought of muffling up for "motoring." Much the same thing is happening in flying. The first machines carried the pilot in a prone position, and it requires no great imagination to visualise how much exposed the aviator would be if called on to cover two or three hundred miles on a cold winter day at a height of some thousands of feet. A little later the pilot's seat was located well in front of the main planes, and served excellently well for those pictures of the "intrepid aviator" which had a vogue for a time. Curiously enough, none of the men who now count in the aviation world were public favourites of this type. Nowadays, however, both pilot and passenger are protected from the weather to a remarkable extent by the deep bodies fitted to even those fast fighting planes where the pilot, in order to loose off a drum at a hostile aircraft, has to stand up. In peace time the fully enclosed body will receive greater attention than ever from the designers, and there will be less need for the pilots and passengers to pay detailed attention to the matter of clothing although, until some satisfactory way of heating the body of the machines is evolved, leather and fur will naturally be in demand.

Accessories in the present sense of the word means those fittings and machines which are brought by manufacturers from outside sources to complete the aeroplanes. Aircraft building is now a huge industry in every first-rank country. Dotted all over Britain, France, Italy, the United States and, of course, the Central Empires, are workshops of greater or less importance making parts of some kind or other for aeroplanes. The industry seems to be settling down into very scientific ways of production; the engines are built in their own shops, the wings and tails and other fuselage parts are also built in separate establishments, and the completed machines are assembled in centralised departments. From the auxiliary workshops all over the country are gathered the detailed components the making of which needs special plant and skilled labour. It may be thought that a new industry of the importance of aircraft would be quite self-contained and independent of outside help, setting up each of its own special departments under the control of the one organisation. Such a procedure is practically impossible. Take an apparently simple thing like rubber tubing. It was soon found that the tubing on the market was quite unsuited to use on aircraft, and the rubber manufacturers were asked to produce a tubing able to withstand petrol, lubricating oil, widely varying temperatures and pressures. Rubber is a most uncertain substance, and the only reasonably safe guide in its working is prolonged experience, so that an enormous amount of experiment was needed before a suitable construction was discovered. For such reasons the aircraft industry must always employ numbers of auxiliary manufacturers, who will specialise in such things as radiators, landing wheels, tyres, wires, magnetos, lighting and engine-starting sets, instruments and other products almost without end.

The growth of demand has been stupendous. Irish linen has been found eminently suited to aeroplane use, and in direct consequence thousands of people are now employed in this direction alone. The average quantity needed per machine is 175 to 200 yards; when America declared war against Germany the Irish mills undertook to supply 4,000,000 extra yards for the 22,500 aeroplanes specified in the official U.S.A. aircraft programme. Linen for the British aeroplanes, it is interesting to note, must weigh not more than 4 oz. per square yard.

Although the aircraft of the future will be of the all-metal type for reasons already discussed, it is a fact that the majority of the machines built during the war were of wood. The average life of a war-going machine was between three and four months, and so one of the objections lodged against the use of wood—namely, its liability to be affected by climatic conditions—did not apply; further, there were stocks of wood in hand and machines to work it. So great was the demand, however, that even the American and Canadian lumber trade felt the pressure. About 1,000 feet of selected timber is needed in each aeroplane, and of this quantity only about 200 feet is actually used, the remainder being wasted in shaping up the struts and spars and in rejected pieces. Before the war only air-dried timber was used, and air-drying is a lengthy process. So lengthy is it, indeed, that the demand had in 1917 caught up with and passed supply, and but for the ingenuity of the Americans the Allies would have been in an uncomfortably tight corner. When the U.S.A. went into the war things began to move at an unparalleled speed. The lumber trade at once signified its ability to provide 75,000,000 feet of selected wood for aeroplane bodywork, in addition to 3,000,000 feet of mahogany and black walnut for propeller making, and, what was more, a special kiln-drying process was invented on which the air-drying business "had nothing," as they say in the United States, in regard to the value of the finished product, and which was also tremendously quicker.

For years the motorist went short of No. 1 petrol, which changed its name unofficially, to

"Flying Spirit." Special carburetters were needed to deal with the fuel over a big range of engine speeds, air pressures and temperatures. American engineers built a special vacuum chamber for testing the engines in under conditions approximating to all air pressures and temperatures. Lubrication systems for aircraft engines were entirely different from motor-car systems; the oil had to be kept cooler and supplied under greater pressure; therefore the oil industry itself underwent considerable changes in its effort to supply what was needed.

The machine-tool and wood-working industries found themselves growing out of all knowledge as the demand for aeroplanes became more and ever more urgent. The machine-tools had to be "fool-proofer" than ever because so many unskilled workers were drawn into the workshops, but in spite of this tolerances or limits of error were finer than ever, and the speed of production was increased. In one workshop, for example, which employs 8,000 women on the making of aeroplane parts, it was estimated that it was necessary for the workers to check over 40,000,000 different machining processes in an ordinary working week of 53 hours. The woodworking machine people found themselves called on to supply all kinds of uncannily ingenious tools. When the production of aircraft reached a stage when some degree of standardisation within types became possible, machines had to be built for the automatic shaping of struts and spars and propellers and dozens of other parts which, previously, had been considered hand work throughout and possible only to the skilled tradesman.

In the metal trades the growth was in proportion. Die-casting, an industry that had struggled for years to obtain the acknowledgment that was its due, suddenly found itself vastly important in the scheme of aircraft matters. Skilled die-casting can save a big expenditure in machining later on. Its products can be guaranteed to very fine limits of decimal fractions of an inch, and when chemists and metallurgists had produced alloys and metals particularly suited to die-casting, very marked advances were made, and other manufacturers began to consider the advisability of purchasing parts which needed practically no machining and could be guaranteed for density, durability and size.

Stamping and forging found itself in much the same boat, but in an adjoining cabin. There is no sense in machining pounds of metal from a heavy forging if the stamping specialist is prepared to guarantee his products to be, as he supplies them, equal in every way to the machined part of the manufacturer; nor is there serious need to cast, say, an engine base-chamber when the stamping process will punch out the parts at a degree of the cost. Quantity production gave these things a spur, for the expense lies more in the making of complicated dies and punches than in the actual work when the preliminary tools are completed. Nor should the accessory side of the metal trade be left without mention of the improvements made in the welding process. At first this business was possible only to men of exceptional training and experience, and the results were not always cheap nor even reliable. As experience was gained, however, the process was speeded up, results became surer, and the cost decreased. Engine makers found increasing use for welding—although it must be admitted that, in the fourth year of war, the Germans had nothing to learn from the Allies judging by the welding on some of the aircraft engines to fall into the hands of the French and British!

In addition to all this, the motor vehicle manufacturers found themselves called on to build completely equipped travelling workshops for the use of aircraft in the field, and lorries for the transport of the aeroplanes overland, to the docks, for example, when the machines could not be sent under their own power. The making of portable buildings for use as workshops, garages, hangars and field offices was speeded up very considerably, and although the reader may ask: "What has all this to do with aircraft accessories, for, surely, these things are purely war-time matters?" the answer would be to the effect that the reader would be mistaken in his legitimate conjecture. These are not purely war-time activities. Always there will be a demand, for although aircraft will not be concentrated in certain regions as during the war, it will increase in volume and be widely scattered all over the world and in outlandish countries oversea, and even in Europe and the United States there will remain a demand for buildings, motor lorries and other things for the service of the aeroplanes.

The paint and varnish industry has increased in direct consequence of the development in aircraft, and the manufacture of dope has almost come to be an industry in itself. Steel cable making has, naturally, had occasion to increase output; the armament firms have produced special light bullet-proof steel for the armouring of aircraft, and the makers of silent chains, although the demand is not anything like so great as it may be in the future when every machine has gearing between engine and propeller, have found it necessary to produce special chains for the new industry.

Use has been found for quite a number of special proprietary articles, as, for example, a bullet-proof glass which is, in addition, practically splinter-proof. Where, to give a clear all-round view, it has been necessary to cut away portions of the main planes, with a bad effect on the flying powers of the machine, this special glass has been found particularly useful. For screens and other similar uses it has, of course, immense advantages. Such things could be multiplied did space allow.

# RAIDS

# RAIDS

some very interesting work was attempted. It was a heterogeneous assemblage of Allied aircraft that set out to bomb the enemy in the concluding months of 1914. The bulk of the French and British machines were hard at work on the Western Front, but there were odds and ends of seaplanes to be had, and occasionally, by some freak of fortune, it was found possible to spare a very few land-going machines, so that in the raids against the German Zeppelin bases in Belgium, French, British and Belgian aircraft all took part. The first raiding was done by one or two exceptionally daring pilots, each of whom was supplied with a map, and who trusted to their own sense of locality and initiative to ensure success.

It was very soon seen that one or two aeroplanes carrying small and comparatively ineffective bombs were of practically no use in inflicting damage against fortified positions, although the smallest bomb dropped squarely on a Zeppelin or its shed was capable of doing a very great deal of damage. At first it was impractical to improve the aircraft or to increase the destructive powers of the bombs, but slowly the number of aeroplanes taking part in the raids increased. There was the disadvantage that the machines were not alike in type, nor had they the same powers of speed, climb and flight

*Photograph by courtesy of the "Illustrated London News"*

A BOMBING RAID BY AEROPLANE

A direct hit from a height of 1,500 feet with bombs dropped from an Aeroplane at Beyrout Harbour.

*Photograph by courtesy of the "Illustrated London News"*

A BOMBING RAID BY AEROPLANE
Hits with three bombs at Beyrout; photographed from a height of 1,500 feet

range. The pilots themselves were not even trained in formation flying, an apparently simple thing, this latter, which is, however, not nearly so simple as would at first sight appear. Later on in the war all the combatants found it profitable to devote great attention to formation flying. One of the most thrilling and, be it noted, one of the most successful of the early raids, was that against the German Fleet lying safely protected, as the Germans thought, behind the defences of Heligoland, Cuxhaven and the Elbe. A squadron of British seaplanes went out, accompanied by a light cruiser force, which hoped both to protect the aircraft and to have a little scrap on its own in case any of the German naval birds were flushed. The ships cruised about just outside the effective radius of the German defences, the seacraft took the air and paid the visit to the German Fleet, doing a considerable amount of damage, and causing considerably greater consternation. Out came Zeppelin airships and aeroplanes, but the British aircraft returned, practically intact, to the waiting cruisers. There are all the ingredients for an exciting novel in this raid, for a well-known British airman fell into the sea with his machine, and was rescued by a torpedo boat destroyer, and a second pilot also came down into the sea and reached England in safety because a British submarine popped up in the near vicinity at the crucial moment and took him aboard, afterwards sinking the seaplane, which it was not possible to salve. It is difficult to estimate the precise damage done to the enemy by a raid of this description, for, very naturally, the pilots do not stand on the order of their going once the bombs have been dropped and the defences are in full cry. It is extremely difficult even to estimate with any great degree of accuracy what new strain has been imposed on the enemy who, when he finds himself vulnerable in some hitherto unsuspected quarter, must considerably strengthen his defences in men, guns and aircraft, possibly to the detriment of some other part of his line where such things might very well have been more actively and profitably employed.

To divert for a moment from actual raiding matters, the Germans were guilty of poor publicity and bad stage management in their official *communiqués* dealing with the Zeppelin and aeroplane raids against England. Again and again the Hun reports claimed that London's docks had been fired and destroyed, famous buildings hit, big railway termini so damaged as to interfere with traffic, inland manufacturing towns and the fortified towns on the coast badly damaged, and barracks and depots and ammunition works completely destroyed. It is always a mistake to underestimate the intelligence of an opponent, and it would be absurd to assume that the German commanders were not kept very well informed indeed as to the exact amount of damage done during these raids. The chief objects of the raids were to inspire terror amongst the civil population, to force the British to keep in the country artillery and trained gun crews which were urgently needed elsewhere, to do what amount of material damage was possible, and at the same time to impress neutral opinion with the story of Germany's might and England's impotence. Had the enemy reports stated that 50 or 1,000 or 10,000 guns, and 1,000 or 20,000 trained men to handle them, were all detained in England as a defence against German attack, they would have had a much better effect on civilian opinion in Germany and neutral opinion elsewhere, and the British people themselves would have worried considerably more than they actually did. These read the German reports, went to see the exact damage done for themselves, came to the conclusion that the Hun was a boasting liar, and went about their business. The lies about the destruction of docks, railway termini and manufacturing centres were very soon detected, and although at first the stories of London in flames made sensational reading in American newspapers, it was not very long before the truth became generally known and the lies discredited. The result is that now, when the countries are at war, every American knows full well that the German reports are aimed particularly at disturbing him without strict regard for the truth—are, in fact, more likely than not, lies also, and therefore much of the intended effect is lost. An interesting study in the German view of the mentality of other peoples.

The art of knowing when and where and how and what to bomb is a complex one which developed with every succeeding month of war. So far as raids against fixed bases are concerned the question of exact date is of no particular importance. Towns and railway stations, for example, are in the same place to-day as next week. But experience demonstrated that air raids against mobile positions and bases have a value not to be despised, and in the third and fourth years of war much of the reconnaissance flying was carried out with a view to supplying particulars for the raiding aircraft which was to follow, and in this, as in other matters, speed became the essence of the contract. Let us assume, for the purpose of citing a case, that an observer in a reconnaissance aeroplane notes ten or twelve locomotives and trains at some railway junction over which he happens to be flying, and notes also the presence of other trains on the railway system all proceeding towards the same junction. There can be only one conclusion. A big store is being established, food and troops are being concentrated, or, very possibly, both of these and possibly other things are happening. A raid undertaken against the junction a week afterwards would have very little or no effect, but a raid carried out within an hour or two of the concentration being seen would in all probability occasion damage and delay. Here is only one instance of the use of raiding aircraft, but there are numbers of other cases of particular work for the raiding aeroplane. As the war continued the raiding aircraft seemed to find new work almost every day. The French and British were less spectacular and only time can show whether they were right or not. In one month of 1917 over 400 tons of bombs were dropped on one of the enemy submarine bases on the Belgian coast.

Valuable as a good defensive in guns, searchlights and aircraft may be, it cannot, in the very nature of things, be nearly as valuable as a successful offensive undertaken against either the works wherein the enemy aeroplanes are built or the aerodromes where they are housed. The British were great believers in this rule and did splendid work against enemy aerodromes following the aeroplane raids against London which followed the defeat of the Zeppelins. Although the full story of one particular raid was not told at the time it may now be told along very broad lines, subject to the Censor's approval. One of the British machines, forced to descend in enemy country by reason of engine trouble, dropped through the ground mist and made a forced landing. While the pilot was cleaning the plugs the observer took a stroll round, for what specific purpose even he at a later date was unable to explain. Unexpectedly he found himself facing an armed German patrol, but retaining his presence of mind and knowing that his leather flying costume betrayed no hint of identity he at once put a question in German as to the locality of the aerodrome wherein the Gotha machines were housed, explaining that the ground mist had upset all his pilot's calculations and that they had decided to ascertain the precise locality. Mistaking the questioner for one of their own men, the patrol supplied the information, and hearing the sudden roar of the engine, the observer thanked his informants, turned and ran for his machine, and, a good ascent being made, was behind his own lines within a very short time. The information thus unexpectedly acquired was put to good use, for later on in the same day a surprise raid was carried out against the German aerodrome where mechanics were hard at work on the fifteen Gothas lined up in preparation for the flight to England. The attacking squadron divided, and while one party bombed the hangars, sheds and field workshops, the other gave its attention to the machines on the ground. Several times the latter swept up and down the line bombing machine after machine. No official figures of this raid were given, although the bombing of the aeroplanes was officially mentioned, but in the messes of the Royal Flying Corps it was generally believed that twelve of the machines had been destroyed, that some further number in the hangars and sheds had been wrecked and, in addition, damage done to the workshops. Whatever truth there may be in the story it is a fact that some very considerable period elapsed before any further aeroplane raid was made against England, although the weather at the time in question was ideal for raiding purposes.

Weather, of course, exercises a very great influence in aircraft raiding. Navigation instruments have now been tremendously improved, but no pilot likes flying in fog for several reasons, one being that he cannot see the country he is flying over, and another that a forced landing means almost certain disaster, and unless high flying is indulged in there is the certain danger of collision with unseen obstacles. The airship has a very great advantage over the aeroplane when flying in fog for it can descend slowly and practically without danger, can re-ascend if the landing cannot safely be made and remain in the air without using up its fuel supplies for any period up to twenty or thirty hours. The same limitations in regard to visibility obtain in both cases. Ideal aeroplane raiding conditions consist of a fairly clear night with the moon rather less than full, with no, or very little, wind and drifting clouds at a height of some few thousand feet behind which cover can be taken from hostile aircraft and the ground defences. Airships prefer a moonless, starry night. For daylight raiding the aeroplane pilot prefers fairly solid cloudbanks at a height of a few thousand feet, above which he can fly secure from all danger but attack from hostile aircraft suddenly descending from a greater height. When these conditions prevail sudden dives through the cloudbanks can be made, the bombs launched, and a return to the cloud cover made before the defences are fully aware from whence the danger is coming. For such work it is necessary to have a good knowledge of the country flown over, in addition to accurate maps, for only by careful calculation and the aid of navigating instruments can the pilot be reasonably sure of being over the objective before the dive is made. Sudden darts below the clouds, however, can be made for the purpose of checking position and locality and, often enough, there are openings through which a bird's-eye view can be taken of the ground below before a shell can be loosed. The disadvantage is that the defensive receives warning of impending attack and is therefore on the alert. What the airman does most thoroughly detest are white clouds at a comparatively great height against which the aeroplane shows in bold relief. Clouds are both friendly and unfriendly to aircraft; they can be hidden behind on occasion, but, on the other hand, some can be accurately gauged in regard to height and velocity, and the aircraft caught diving through clouds on which the anti-aircraft guns are registered has a very sorry time of it.

Isolated raids are not as a rule of great value, for in most cases the damage done can be quickly repaired. In order to get the best effect continuous attacks are necessary, so that the enemy cannot make use of the bombed places, and has, in addition, to divert men and guns to the defensive. In 1917 the Italians raided Austrian towns and bases on the Adriatic coast with the deadly regularity of a mail service. For hours at a time Italian aeroplanes flew over at four-minute intervals, until the Austrians stopped their attacks by air against the Italian towns. So thoroughly were the raids conducted that the defences were completely disorganised and the Italian losses were infinitesimal. The French and British also raided places of military importance behind the lines on the Western Front daily and nightly for months on end, only the very worst weather keeping the machines in their aerodromes. Railway junctions, flying grounds, ammunition dumps, general and divisional headquarters, each and all were "spotted" during the day and bombed by night. The Germans also developed this raiding of military objectives behind the lines, and, as in most other things, they began with some little advantage in hand, an advantage that was, however, later wrenched from them by the Allies. One lesson the German raiders taught when they demonstrated to the British the folly of big centralised railway junctions and exposed ammunition dumps in the beginning of 1915.

When formation flying received the attention its importance deserved, the thing became almost a science. Bird flight gave a clue to what was needed, and the bombing squadrons in 1917 took in the air the shape of a triangle flying apex forward, the individual machines maintaining different heights. The leader takes place of honour at the point of the triangle, and the others, strung out behind him, have the advantage of seeing where the first bombs fall and correcting their own aim accordingly. When aircraft fly in this formation it is difficult for the ground guns to register on more than one machine at a time, for to swamp the whole squadron there would have to be very rapid and effective means of communication between the ground defences. Fast single-seated fighting machines accompany the raiding squadron, flying on either flank, and some thousands of feet above, and it is the special work of these to beat off the attacks of hostile aircraft while the bombers are registering on the objective below. A special type of fighter is necessary, for it must have a big flight range in addition to speed and power of manœuvre. The fighting machines used with the armies in the field are highly specialised units of extremely limited powers. Being never very far away from their base, there is no advantage gained in carrying unnecessary fuel supplies, and their work in consequence is sharp and sudden. The units accompanying the bombing squadrons, however, are in very different case, for they must have a flight range equal to that of the heavier machines, and no great disadvantage in performance when compared with the fast and lighter scouts sent up by the defence. Although the attacking force on starting is heavily loaded with fuel and ammunition, dead weight has been considerably reduced when the objective has been reached, because approximately half the fuel supply has been used, and when the bombs also have been released, both speed and climb increase. A 400 or 500-mile round flight in 1917 represented a high-class bombing performance, and as it would be folly to send up defending machines with fuel insufficient for at least 100 miles of flying, when a single running fight may easily cover 50 or 60 miles, the advantage to the defenders is not so great. Successful defence by aircraft against aircraft depends on forcing an engagement before the objective has been reached. The bombing machines themselves are not fast craft as things go, but, on the other hand, they are of distinctly good performance when weight has been reduced by consumption of fuel and the release of the bombs. They are, however, awkward opponents to meet in air attack, for the latest types are each fitted with several machine-guns. A squadron flying at 80 or 90 miles an hour, and able to bring concentrated fire to bear from anything between 20 to 100 machine-guns, is calculated to make things very unpleasant for any daring aircraft flying close enough to attempt individual combat. In the latest designs, also, the " blind " spots have been almost entirely eliminated by careful design, and in the Gothas the fuselage is tunnelled out to mount a machine-gun for driving off attacks " on the tail."

The day will undoubtedly come when squadron fighting in the air will be a recognised feature of aerial warfare, and other things being equal victory will lie with the squadron leader or general most skilful in strategy and the deployment of his forces. Almost, it will be a case of naval manœuvring again when Nelsons of the air will come into their own. A skilful general will solve the problem of cutting out weaker sections of his opponent's forces and destroying them by concentrated attack, and every effort will be strained to force the enemy into the manœuvres most desired by his opponent—the essence of strategy and tactics, it is said, being the power to force manœuvre on the enemy.

Different type machines and formations will eventually be employed for special purposes, practically the only rule which can at present be laid down is that all the machines comprising a squadron must be alike so far as speed, climb and other matters are concerned. Unlike a chain, the speed of an air squadron is not equal to that of its slowest unit, but rather to the fastest, the slowest unit simply being in need of all the sympathy it can get. In naval work squadrons are divided into ships of the same class, and any ship which falls out of line in action owing to slow speed or injury is practically doomed to destruction. The rule was well illustrated in the case of the Blucher, sunk by the British on the occasion of one of the last German cut-and-run raids in any force against the English coast.

Raids against big towns during the great war caused an amount of confusion and distress quite apart from the actual casualties and damage done. It became necessary to train and discipline the civilian population, and the case of London showed how this could be done. A considerable percentage of the millions of its population was afforded shelter in such places as tube railways, underground subways, church crypts, and in the basements of bomb-proof buildings during the raid periods. The people rapidly became accustomed to take notice of the "Take Cover" and "All Clear" announcements and warnings, and after a while the system worked like machinery. At the best, however, this was making the most of the means conveniently to hand, and it is doubtful, even if the use of aircraft be prohibited by international agreement, whether raids by air will never again take place—the probability being, indeed, that they will grow in intensity in the future—buildings, and even cities themselves, must be constructed with a view to being more or less bomb-proof. It would be little more expensive to build practically a bomb-proof building than inadequately to protect it by means of steel guards and other makeshifts. Very probably insurance companies will offer special inducements by allowing premium concessions on bomb-proof buildings, and while the world is not likely to witness within the next few years the creation of cities armoured like gun-turrets, nor the development of a warren-living populace, there is every reason to suppose that there will be a growing tendency greatly to strengthen roofs by the use of thick layers of steel and reinforced concrete.

There is one aspect of raiding which will interest even those countries which in the past have imagined themselves comparatively free from attack by reason of their geographical situation and dividing seas. Aircraft will bring about a reconsideration of the position of these, just as the English have had to readjust their views about the impregnability of Great Britain because of its salt water defence. Great Britain is no longer an island in the military sense, nor is either North or South America. The day when great fleets of long-range aeroplanes can leave Europe for the purpose of bombing American cities is no doubt some considerable number of years in the future, but the day when New York, Sydney or Cape Town can be bombarded by a European aeroplane is . . . to-day! In writing this there is no sensational desire to harrow the feelings of our American Allies, but the truth is that the American cities on the coast-line are now, in this year of grace, at the mercy of Germany, far more so than either London or Paris, granted only Germany had the time and machines at her disposal. A present-day submarine could house half-a-dozen seaplanes by a little readjustment of internal arrangements, and half-a-dozen such craft could unload a very destructive air fleet for an attack on New York without exposing itself to any great danger other than the Allied naval defensive against the submarines. Within an hour's flight of New York the seaplanes could emerge and the bombs carried by the aircraft would be much heavier and far more destructive than those used in the attacks against London, because there would be no need for the aircraft to carry petrol for an extended flight. Several trips could be made in the course of one night, the machines returning to their submarine base and replenishing bombs and fuel as required, and there would be a dis-

A FOKKER DIVING FOR AN ALLIED AEROPLANE

Until the Allies were able to build faster and more powerful machines the high-flying power of the Fokker made it a very dangerous antagonist.

AN ITALIAN AEROPLANE WHICH SECURED MANY RECORDS IN 1917.
NOTE THE CAR-TYPE RADIATOR

tinct possibility also of the aircraft escaping without serious casualties. The fate of the submarines would be quite another matter, but even yet Germany may decide that the attempt is worth the risk. Because the American towns are not defended by searchlight or gun the aircraft could fly at such low speeds and heights that there would not be a hundred to one chance of their missing their objectives, and with the more destructive missiles used the damage would be immensely greater than in attacks again London or Paris.

In future wars between nations with any pretence to naval power it will probably be impossible to contain the enemy fleet as the British Navy has contained the German, and where powerful fleets are at sea accompanied by seaplane motherships there would always be the chance of sudden and possibly devastating attack against cities located anywhere near the freeboard of a country. Here a nice problem arises as to whether the defence of the future will consist in the provision of anti-aircraft guns and searchlights, together with the creation of a big aerial fleet for defensive purposes, or the rebuilding of towns and cities with a view to practical immunity from aerial attack. A famous novelist, writing of life on one of the other worlds, created an underground people, and what a few years ago seemed far-fetched romance may, in the not too distant future, prove stern fact.

Towards the end of 1917 there was a new development in bombing by aeroplane, which reached its greatest intensity in the great British victory of the Third Army under the command of General the Hon. Sir Julian Byng, the victory known to the man in the street as the "Battle of the Tanks." General Headquarters in France announced that despite considerable mist the British aeroplanes worked throughout the day in conjunction with the troops. Low clouds and mist and a strong westerly wind with drizzle and occasional rain throughout the day made it necessary for the British pilots to fly at 50 feet from the ground, and even at that height the machines were at times quickly lost to view. Continual attempts were made to maintain contact with the advancing troops, but as this was made almost impossible by the weather conditions the machines had a real joy day in bombing anybody and anything of enemy origin coming within their range. Thousands of bombs were dropped on the enemy's batteries, lorries, aerodromes, transport and railways, and batteries and small groups of infantry were attacked by machine-gun fire, valuable information being gained despite the very difficult conditions. The work of the bombing and raiding machines in this battle, indeed, reached high-water mark for 1917.

The question of defence against aerial attack must in the future prove a considerable problem to the military authorities in any country. In the early days of the war the gun was the greatest enemy of attacking aircraft, and when the Germans first raided Paris they were quite safe from ground fire at a height of 4,000 feet, for at that time the trajectory of the French shells was, with any degree of certainty, in the neighbourhood of 3,500 feet. As a matter of fact the German raiders got away uninjured, and the Allies were forced to console themselves with the idea that at 4,000 feet it was impossible for calculated aim to be taken, and, therefore, the chances of material damage being inflicted were exceedingly slight. What, however, had been an age-long problem before between the gun and the armour-plate became a new battle between the gun and aircraft. As the trajectory increased aircraft began to fly higher, and with increased height and greater speed came more powerful bombs and a better aim. But continually the gun drove the aeroplane farther, and continually the latter improved, until fairly effective bombing was being done at any height between 12,000 and 20,000 feet, and, against this, the guns were registering hits at 15,000 and 16,000 feet. The first anti-aircraft guns were simply light field pieces which were given a few greater degrees of elevation, and very ineffective they proved. As time went on, however, the gun, together with the ranging and sighting apparatus, improved, and the gun crews became more experienced until, unless the pilot proved extremely skilful and was assisted by climatic conditions, it was a foregone conclusion that a direct hit could be made at anything up to 12,000 feet. This, of course, applied to machines flying in the daylight on which individual guns were registered, and of which the leading dimensions were known. At night time it was an entirely different matter. The Zeppelins, after a while, were comparatively easy game. At 10,000 feet the guns chipped off any particular part of the airship that the artillery officers took objection to, and, driven above this height by shell fire, the Zeppelins became the prey of the aeroplane and the other weapons of defence which everybody in Europe knew and talked of, but which could not be written about in war-time without grave offence to the authorities. But no amount of good individual shooting afforded any great protection against the aeroplane raiding at night. Their small size, their speed, the heights at which they flew, all made it comparatively easy for them to elude the searchlights which, once they had ringed an airship, made either destruction or surrender the only alternatives to the commander.

Aeroplanes, however, can dive much quicker than airships, and so gun defence against raiding aeroplanes was developed to its logical conclusion in the barrage which the British put up round London when attack threatened. The barrage formed a curtain of fire through which no aeroplane could fly without great danger, and it also had the advantage of ensuring that enemy aircraft flew at approximately known heights, with corresponding advantage to the British aircraft hovering some thousands of feet higher. Before the barrage was complete enemy aeroplanes flew round in a big radius feeling for a weak spot in the defences, and, for a time, some of them also escaped destruction by flying at very low heights which took them well below the fire curtain. When the gun defences were completed and numbers of howitzers added, the defence became so efficient that instead of attacking on every favourable night as the Germans at one time hoped would be the case, they were forced to try the effect of surprise raids in the hope of taking the defensive unawares. Some additional consolation was found in the idea that men and guns were retained in England which might possibly have been of greater service in France—not to such an extent, however, as to call for any special congratulation from the Kaiser or Hindenburg.

Practically every form of raiding and bombing by aircraft was resorted to by the belligerent nations at some time or other during the war, but it was left to the Germans—that race of Kulture—to bomb hospitals in order to ease the pressure of an attack on their forces. The official records are in existence. Copies should be placed on view in every library and museum and public institution throughout the civilised world, that all posterity may know the Hun for the unclean thing. French hospitals, distinguished by the illuminated Red Cross, were repeatedly bombed by German airmen at intervals throughout several nights during the course of a French offensive. There could be no plea of mistake, for the airmen descended so low that observers from the ground could pick out with the aid of night glasses the crosses on their wings and, obviously, if these could be seen the Germans could have no difficulty in picking out the Red Crosses illuminated from below which were in size almost equal to the aeroplanes themselves. More than this, when the attacks grew so persistent that it was decided to remove the patients, the aeroplanes followed the ambulances along the roads and bombed them as they went, the upshot of the business being that nurses, doctors and wounded men were deliberately murdered by attack from the air. Such is one aspect of raiding from the cultured Hun point of view.

# FUTURE COMMERCIAL DEVELOPMENT

# CHAPTER XI

## FUTURE COMMERCIAL DEVELOPMENT

WONDERFUL as the work of aircraft in war has been, and enthusiastic as are the professional soldiers and sailors about its future, informed opinion throughout the world holds to the view that the aeroplane has most promise for humanity in its commercial development. Indeed, aircraft is no more a special weapon of war than is the locomotive or steamship. Man is not essentially a fighting animal because he has treated war in a scientific manner. He fights, and fights well, because he has to, for, paradoxical as it may seem, he dies that he may live, and although the locomotive, the steamship, the spinning machine, machine-tools and the motor-car are all used in war, they are of the greatest service to man in peace. So it will prove with aircraft. Let it not be thought for one moment, however, that in this lies a suggestion that in future wars the use of aircraft will be forbidden. Man will not deny himself the use of one of his greatest inventions, and if aircraft is to be used in times of peace assuredly it will be used in war; but in peace aircraft will be developed to the *n*th degree, and as to the precise value of this numeral only the future can have an opinion.

The ordinary man is of the opinion that the dangers of flying will detract from its extended use in the future. As to this, it is sufficient to quote the official British statistics, which are to the effect that, excluding war casualties, there has been in England during three years, when many thousands of civilians have been taught to fly, a number of fatal accidents which total out to one death in over 125,000 miles of flying—or, put in another way, one death for each five flights around the earth. Assuming, then, that aeroplane work is no more dangerous than motoring, its possibilities as a weight carrier may be considered. Progress in this respect is limited only by strength of materials, available engine power and effective design. Such things as fuel consumption, running costs, and other matters of a similar nature are—although to the lay mind it may seem rather absurd to say so—in reality matters of everyday detail which will be automatically solved as further experience is gained. Concrete instances are more illuminating than any amount of conjecture and supposition, and, therefore, in order to support the case for the aeroplane as a load carrier, it may be said right away that a British-built aeroplane, carrying 20 passengers, flew at a height greater than 8,000 feet and reached a speed well in excess of 70 miles an hour in 1916. Very obviously also the peace-time aircraft will not need to carry a heavy load of bombs, and there are many things at the present time light and portable, such, for example, as press messages, which could be transported at express speed and comparatively profitable rates by aeroplane, from England to the Continent, between various centres on the Continent, and between America and Europe and the other continents.

It is not suggested that these long-distance and trans-ocean flights will be accomplished in one mouthful, so to speak. There is no particular need or urgency—apart altogether from the very few and special machines which will undoubtedly do long journeys at top speed and at an uncommercial cost very similar, indeed, to the special trains in which millionaires occasionally indulge themselves—for long non-stop flights, when suitable landing stages can easily be provided. Just as for steamships and locomotives docks, stations, sidings, warehouses and exchanges are provided, so must adequate facilities be created for aircraft. Agents must be appointed in every country, town and port; repairing facilities must be world-wide; regular understandings as to the use of aircraft must be arrived at by international agreement, and very possibly the big sea bases which will no doubt be established at various selected points in the Atlantic, Pacific and other oceans, will be used impartially by all the nations. Undoubtedly, also, the respective Governments will be called on to assist by subsidy aerial services engaged in both passenger or mail transport. There are those who would argue that neither the aeroplane nor the airship can transport motor-cars or grand pianos. To these it might be answered, in all logic, that the locomotive itself would have difficulty in transporting, say, a suspension bridge unless that bridge be reduced to its simplest parts and transported piecemeal. One should look rather at the work the aeroplane and the airship actually can rather than at what they cannot do. Fog and climatic conditions are undoubtedly, and possibly always will be, something of a handicap, but at the same time no more a handicap to aircraft than to other forms of transport. The fog holds up the railway train and calls, even before very limited movement can be indulged in, for the instalment of a system costly to set up and expensive to operate. So it would be with aircraft in fog, and as to the storm which sinks the passenger liner and the cargo ship without distinction of class or kind, the aircraft would be able to rise above the disturbed area, and while it is possible that mishap in the air may lead to complete destruction, there is little chance of either the airship or the aeroplane smashing itself on a rock. The dangers balance out. There is the further advantage in aircraft that it is independent of any special track. It requires neither rails nor overhead wires, and above all is the advantage of speed. Present-day speed in itself passes all the imaginings of the novelist, and as to operating cost the engine is practically the same as a car engine, costing the same to buy and the same to operate, power against power. There are few who are now prepared to dispute the advantages of the commercial motor as a transport unit, and although aircraft may call for greater power than a motor vehicle it has a corresponding advantage in lower operating cost. It has no tyre costs at 2d. per mile to provide for, to give only one example.

The writer now proposes to quote from a lecture given by one of the leading authorities on aircraft, Mr. G. Holt Thomas, before the Aeronautical Society of Great Britain in May of 1917. Mr. Holt Thomas himself suggested that his effort was largely one of the imagination, but as he is one of the foremost constructors in England, and a far-sighted business man who looks far beyond the war to the time when he must find a market for his aeroplanes other than Governments who desire them for war purposes, it may be taken for granted that the majority of the statements made are based on fact:—

"The subject I have to deal with in this paper is enormous, and of vital importance to the Empire, but it is only possible to touch very lightly on the possibilities of commercial aeronautics in the time allowed. My opinion is that it will revolutionise the world not only from a commercial point of view, but from a humanitarian point, much more indeed than it has revolutionised warfare, although the effect on that is very great. Commercial aeronautics are not going to beat railways and other forms of transport out of existence, but flying will act as an adjunct to the present modes of transport. The question which we have to decide is: 'Can the aeroplane, taking into account the advantages of speed, etc., which it alone possesses, be regarded as a practical means of transport?'

"The question naturally arises as to in what way will aircraft be used commercially after the war. To prophesy for such a new science as flying is almost impossible, but many instances will crop up for the use of commercial aeroplanes. Surveying, for instance. I am told by my friends amongst the large contractors that it would be worth an enormous sum to be in a position not to know where to go, but to know where not to go; and the production of some sort of cinematograph machine for the purpose has already been tried and certainly will be produced. For those in a hurry: Nothing can compete with the aeroplane for those on special services in need of the greatest speed possible. This alone opens a very wide field indeed.

"From a business point of view it must be remembered that speed is everything. One saw this in pre-war days in the competition between the steamship companies in the race across the Atlantic. A special aeroplane—*i.e.,* special used in the sense of special train, which is perfectly feasible to-day—will enable the business man to leave London in the morning, do his business in Paris, and be home again to dinner. It will take him to Bagdad in a day and a half or New York in two days. Many business men would smile at the idea of using this mode of conveyance to-day, but the only thing is to remind them that they also smiled in the early days of motor-cars, and yet half the business to-day would take double the time to do if the motor-car were not in existence.

"A parson in a far-off Colony has already proposed to use a seaplane to fly round the coast, across the bays, etc., and so visit his parish in hours instead of months of tedious travel.

"Rivers, again, suggest a very probable and certainly useful employment of aeronautics, using them as a line of flight. Huge districts in many localities, such as Africa, are controlled by officials who usually employ the river as a means of transit, using motor launches, and then inland from the nearest point. Think of replacing this by the use of seaplanes doing 100 miles an hour. This equally applies to mails. South America, Canada, Asia, all come into this scheme, and no landing ground is required. Nature has supplied it in the form of a smooth-surfaced river. Again, these ready-made roads could be followed at night, with a searchlight on the machine, with the greatest ease and no danger.

"The Cape to Cairo Railway again affords simply an instance, which occurs over and over again in that and other countries, where an aerial service might be employed as an adjunct to the railway. The present method would probably be one's arrival at a wayside station and then, say, 50 miles in a bullock wagon, or perhaps walking, over jolty roads, or no roads at all, taking one or several days. Compare this with stepping into an aeroplane and arriving in half an hour. Certainly the development of all the Overseas Dominions will be largely affected by flying.

"It would astonish a great many people to know that the running costs of an aeroplane are not more than those of a motor-car. Some years ago I gave particulars of four types and the running costs in the air as follows:

| | | |
|---|---|---|
| Type A | 2¼d. | per mile |
| Type B | 4¾d. | " " |
| Type C | 5½d. | " " |
| Type D | 3½d. | " " |

"These figures, of course, refer to peace times so far as cost of petrol, etc., is concerned, but it refers to an old type of machine with about half the speed of the present-day machine. Repairs should cost less, if anything. Here are figures of the running cost per mile in the air of later types of machines. These may all be put down as doing considerably over 100 miles an hour, but we will take them as covering 100 miles an hour, although personally I think that the wind will average itself, that is to say, one day it will be against and another day with the machine. The cost of these machines in the air is as follows:

| | Per Mile. |
|---|---|
| A. Carrying useful load of 1,800 lbs., including pilot and fuel | 6½d. |

| | Per Mile. |
|---|---|
| B. Carrying useful load of 1,000 lbs., including pilot and fuel | 5d. |
| C. Carrying useful load of 450 lbs., including pilot and fuel | 2½d. |

"Now in talking about the cost of aircraft as compared with other forms of transport, I have so far only dealt with the running costs, and have shown you how very cheap it is, but in order that the whole of the aeronautical industry should not leave the room to register aerial transport companies, it is necessary to go into figures much more deeply, as there are other costs besides running costs. On the other hand, it is necessary to remember that before you can use a motor-car, or a motor-lorry, you must have a road on which to run it, and the average cost per mile of this road in capital expenditure alone may be put down as about £6,000 per mile.

"A railway train before you can run it requires a capital expenditure which, taking the average of various countries, may be put down as £24,000 per mile. Taking, therefore, a journey of, say, 100 miles, as we must have some unit, the capital expenditure, apart from running cost, comes out as follows:

| | |
|---|---|
| Railway | £2,400,000 |
| Aircraft | 60,000 |

"I do not for one moment suggest that, once the capital outlay on the railway has been made, it will not carry, to a huge extent, much more traffic than the aeroplane line, but until that traffic is forthcoming the aeroplane will, firstly, do it without such capital expenditure, and, secondly, will always do it very much faster.

"The natural obstacles encountered by the railway and the road may be unsurmountable. The air is free of any such obstacles.

"I will now take you through the costs of a sample route, and I suggest London-Paris as an instance. We can take it that if the journey is done in half the ordinary time we shall have mails and passengers—some because they want to get there quickly, others because they wish to avoid the Channel crossing, and a good many, at first, for curiosity. Now, to start a commercial service, we are not asking for millions of passengers or tons of mails; we are not thinking of rivalling the Tubes.

"In putting these before you I would make it quite clear that they are costs of to-day, which I think it is right I should take, as if I begin to prophesy you will doubt me at once. At the same time I have not the slightest doubt that these figures, as time goes on, will come down enormously (just as the cost of running omnibuses has come down since the time when the first petrol omnibuses nearly ruined every company running them) and I would like to say without much misgiving that within a certain period you may halve them.

ESTIMATE D. AERIAL SERVICE, LONDON—PARIS.

*One machine each way daily.*

Carrying 2,500 lbs., less petrol and oil and pilot, for, say, 300 miles.

| | | Per Mile. | |
|---|---|---|---|
| Capital— | | s. | d. |
| 9 machines at £2,500 . . . . . . . . . . | £22,500 | | |
| Working capital, say . . . . . . . . . . . . | 12,500 | | |
| | £35,000 | | |
| At 10 per cent. interest per annum, £3,500, or £9 6s. 8d. per day for 600 miles. . . . | | 0 | 3½ |
| Sheds— | | | |
| London . . . . . . . . . . . . . . . . . . . . . . . | £500 | | |
| Dover . . . . . . . . . . . . . . . . . . . . . . . . | 200 | | |
| Calais . . . . . . . . . . . . . . . . . . . . . . . . | 200 | | |
| Amiens . . . . . . . . . . . . . . . . . . . . . . . | 200 | | |
| Paris . . . . . . . . . . . . . . . . . . . . . . . . . | 500 | | |
| | £1,600 | | |
| Say £4 10s. per day for 600 miles. . . . . . . . . | | 0 | 2 |
| Labour— | | | |
| London . . . . . . . . . . . . . . . . . . . . . . . | 12 men | | |
| Dover . . . . . . . . . . . . . . . . . . . . . . . . | 2 " | | |
| Calais . . . . . . . . . . . . . . . . . . . . . . . . | 2 " | | |
| Amiens . . . . . . . . . . . . . . . . . . . . . . . | 2 " | | |
| Paris . . . . . . . . . . . . . . . . . . . . . . . . . | 12 " | | |
| Total . . . . . . . . . . . . . . . . . . . . . . . . | 30 men | | |
| At £3 10s. per week equals £15 per day for 600 miles . . . . . . . . . . . . . . . . . . . . . . . . | | 0 | 6 |

ESTIMATE D.—Continued—

| | | Per Mile. s. | d. |
|---|---|---|---|
| Pilots— | | | |
| 3 flights one way per week per pilot requires for 14 flights per week 4½ pilots, reserve, say, 1½ pilots, equals 6 pilots at £500 per annum each equals £3,000 per annum, say, £8 5s. per day for 600 miles | | 0 | 3½ |
| | | 1 | 3 |
| =2,000 lbs. for Utility Purposes. | | | |
| Machines— | | | |
| London | 2 | | |
| Dover | 1 | | |
| Calais | 1 | | |
| Amiens | 1 | | |
| Paris | 2 | | |
| Spares | 2 | | |
| | 9 | | |
| Running Expenses— | | | |
| 24 gallons petrol and 5 gallons of oil, taking speed at 100 miles per hour | | 0 | 8 |
| Depreciation and Repairs— | | | |
| Allowing complete overhaul every 100 hours, flying 300 miles per day at 100 miles per hour, equals overhaul every 33 days; 25 per cent. off two machines at £2,500 each equals £1,250 equals £38 per day for 600 miles | | 1 | 3 |
| Overhead Charges— | | | |
| Management | £3,000 | | |
| Clerical work, etc. | 1,600 | | |
| Advertising, etc., each end | 6,000 | | |
| Offices, etc. | 1,000 | | |
| Contingencies | 2,400 | | |
| | £14,000 | | |

| ESTIMATE D.—Continued— | Per Mile. s. | d. |
|---|---|---|
| Say £40 per day for 600 miles.............. | 1 | 6 |
| | 1 | 3 |
| Total cost per mile .............. | 4 | 8 |

ESTIMATE F. PARIS—LONDON.

*Profit and Loss.*

Passengers—

Cost, say, 3s. per mile.

300 miles = £45.

2,000 lbs. = 12 Passengers.

Cost per Passenger, £3 15s.

Charge per Passenger, £5.

Profit per Machine each way daily, £15.

| | | | | | | Per annum. |
|---|---|---|---|---|---|---|
| 12 | Passengers | each | way, 4 machines. | Profit | .. | £43,000 |
| 11 | " | " | " | " | .. | 30,000 |
| 10 | " | " | " | " | .. | 14,000 |
| 9 | " | " | " | " | .. | — |
| 8 | " | " | " | Loss | .. | 14,000 |
| 7 | " | " | " | " | .. | 29,000 |
| 6 | " | " | " | " | .. | 40,800 |
| 5 | " | " | " | " | .. | 58,000 |

and so on.

ESTIMATE G. *Profit and Loss.*

Mails—

Load, 2,000 lbs. = 32,000 ozs.

Cost per oz., ⅓d.

Charge, say ½d.

Charge, 3 lb. parcel, 2s.

Full load each way, 4 machines. Profit, £60,000 per annum.

Three-quarters load each way, 4 machines. Profit, £14,000 per annum.

Half load each way, 4 machines. Profit, £35,000 per annum.

And so on.

Total cost of 4 machines each way, £130,000.

ESTIMATE H. LONDON—MARSEILLES.
8 hours.
Passengers, £10.
Mails, 1d. per oz.

ESTIMATE J. LONDON—CONSTANTINOPLE OR MOSCOW.
20 hours.
Passengers, £25.
Mails, 2½d. per oz.

"Now you will have seen from these costs that I have put before you that passenger services are not high for the speed of journey, and present a really commercial proposition, although at a competitive price they are slightly higher than by train and boat, whilst mails present an easier proposition, and it seems to me that the solution is a mail service subsidised by the Government with the right to carry passengers.

It is certain that the aeroplane is going to be used by business men for business purposes. No other mode of transport can touch it. Whether it costs 5s. per mile or £5, the business which can be done on certain occasions will only be done by arriving in time.

"It will be seen from Est. D that the total cost per mile of running a machine is 4s. 8d., running one machine each way. It is only fair to assume, however, the cost would be much lower if two, three, or four machines are run each way daily, and I think it is fair to assume that between two capitals, such as London and Paris, at least four machines each way will be necessary. We can therefore for the purposes of this paper take 3s. per mile as being a safe figure.

"Est. F shows how this cost, reduced to passengers, will come out. It will be seen that the charge per passenger to Paris, at a profitable rate, so long as the machines are fully loaded, comes out at £5, which at the speed he is carried is certainly a commercial price. It will be noticed here by the figures shown at the bottom that whilst there is a good profit if the machines are full of passengers, a reduction in the full load very easily turns the profit into a loss, and this is one of the points which will have to be considered very carefully indeed. The services *must* be started, and either subsidies or guarantee against loss *must* be forthcoming.

"Est. G shows that mails are even more commercial—that is to say, a letter weighing one ounce can be profitably carried to Paris for one halfpenny in half the time it could reach there under the present methods, or a 3 lb. parcel for 2s. Here, again, it will be seen that profits can be made carrying full loads, but directly the load is reduced it is quite easy to make a heavy loss.

"From Est. H you will see that, based on our

London-Paris costs (Est. D), a passenger can go from London to Marseilles in eight hours instead of 23, at a cost of £10 per head; or that mails can be carried at a penny per ounce.

"Est. J—Constantinople or Moscow can be reached in 20 hours, at a cost per ticket of £25; or mails at 2½d. per ounce, both of which I think proves still more the future of commercial aeronautics.

"For mail services I am certain that the aeroplane can by its speed and moderate cost per letter compete with existing mail services. I have always held these views, and they are expressed very simply by the fact that I arranged with Mr. Grahame White seven years ago to carry mails from Blackpool to Southport, and endeavoured to interest the then Postmaster-General in it. Specialised services of all sorts will exist also. I have taken the cost of London-Paris, as it is a familiar route, and probably the most expensive, but there is another outlet for commercial aeronautics than from capital to capital—viz., providing a means of communication by which at comparatively small cost a moderate-sized community or colony may be established, say 100 miles from the railway, in many of our Overseas Dominions, and whilst small will depend on the aeroplane, and when grown large enough will have its railway. In other words, the new science of flying may be regarded as a means of development, as a feeder for the railways existing, or without laying a road at all either for motor-cars or railways, until development warrants them. Certainly on the start of such services a Government subsidy or guarantee will be an absolute necessity.

"Now another thing which you may doubt, but of which I have had considerable experience, is reliability. You can gauge this in any way you like. How many machines cross the Channel daily? How many machines fall into it? I am afraid I cannot answer these questions. But within my own experience, even with machines not nearly so reliable as those of to-day, I have no doubt about the reliability. My company, the Aircraft Manufacturing Company, has been in existence since 1911. It has delivered—I cannot tell you the number—but a great many machines to Farnborough. The only stops we can record are in four cases, and in every case these were only ordinary stoppages, such as in the case of a car with a choked petrol pipe, or something of that sort. I will also give you a few recent instances of practical uses of aeroplanes, again within my own knowledge, although I am certain these would be confirmed and multiplied if I were to ask outside.

"A short time ago the War Office required one of our managers at Chelmsford for a certain purpose. They telephoned at about 11.20 saying that it was absolutely necessary for him to be there by 12 o'clock. Here is an instance where aircraft presented the only means of transit. Again, a recent instance is a case where the War Office telephoned asking Captain Hucks to go to Huntingdon to test a machine for them. The actual distance there and back is 116 miles, and Captain Hucks's flying time there and back was inside an hour. I believe General Brancker, time after time, has visited various aerodromes by air, putting in visits during the day which would be perfectly impossible with any other mode of transit. I met Captain de Havilland one evening at Boulogne by accident, he having flown from Farnborough to Headquarters in 1 hour 25 mins., and he tells me that this must have been surpassed many times.

"Another point which will be brought up against flying for commercial purposes is weather, and this we may, I think, divide into wind and fog.

"Now, as to wind, it is to-day almost safe to say that no wind will stop a good pilot from flying. Over and over again we find in the official *communiqués* that during hail, snow and storm our pilots are flying.

"I should now like to touch on a subject which, in my opinion, is very important to commercial aviation—viz., the question of landing grounds, and my view is that we shall have to establish landing grounds all over the country and all over the world not more than, say, 10 miles apart. In talking, say, of a voyage from London to Constantinople, this sounds a stupendous undertaking, but if analysed one finds that it is quite simple.

"Allowing £250 per annum as the cost of hiring and maintaining a landing ground, it means that from London to Constantinople, 1,600 miles, the landing grounds would be 160, which, at £250 per annum each, would be £40,000 per annum. What is this spread over the countries through which this route would pass, assuming the importance of having this very vast connection all over the world? But, looking at it in another way, even if the cost of a landing ground was paid by the machine which passed over it, it is almost an infinitesimal matter. Taking our previous figures of London-Paris, with eight machines per day—*i.e.,* four each way, the number of machines passing over the landing grounds between London and Paris would be 2,920 per annum, and a tax of about 2d. per mile on each machine would return the whole costs of the landing grounds. But the London-Paris route will also be the running line for many other services beyond Paris and London.

"I regard the landing grounds as being of the greatest importance. To start with, no country can have machines flying over it without control, and therefore a landing ground on entering a country is necessary, putting it on the lowest ground even of smuggling goods into the country. Then, again, I believe if I asked anyone in this room to fly from London to Tokio they would say, 'You will never arrive there,' but, on the other hand, if I asked them to fly 10 miles, they would know that they would certainly arrive; and therefore to credit what I have told you so far, I am going to tell you it is important to regard these long distances as merely 10-mile stages. This question of landing grounds affects every point in my argument. Safety, for instance. The forced landing, the bugbear of aviation, will be avoided, as a pilot with a machine at a height of 3,500 feet, even if he stops exactly in the middle of two landing grounds, will arrive at either, but the probability is that he would be very much nearer one. We may therefore consider London to Tokio as aerodrome flying—that is to say, the pilot will always have a flying ground to alight on. As regards the pilot, he will have no strain in keeping his eyes open for a landing. He will simply fly on, passing Flying Ground No. 27, 28, 29, etc., knowing that he is always safe if his motor stops at any moment.

"Then, again, the question of fog will certainly be overcome at once by 10-mile landing grounds. Some form of mark will easily be developed, such as a smoke signal, some form of penetrating searchlight, or some other device such as the small kite-balloon I have recently devised.

"The question of night flying is again solved by the landing ground, as with a searchlight every 10 miles a pilot can fly on regardless of maps or routes, always with the searchlight guiding him.

"I am not, of course, suggesting that landing grounds should be aerodromes; they would be simply suitable fields, which need not be absolutely on the line of route, with probably a telephone box, and some with searchlights and some with sheds. This scheme has already been carried out in Italy, and has been entirely successful, as I believe I am safe in saying that the cost of the landing ground has practically been repaid by the saving in smashes on landing in what is a somewhat difficult country. Through the courtesy of Major Perfetti, of the Italian Flying Corps, I have seen an illustration of a portion of the map showing the landing grounds, etc.

"Now I will ask you to accept this idea of the 10-mile landing ground as being perfectly feasible from a national point of view and from an international point of view, but it is a matter in which Great Britain and the British Empire should take the lead.

"The landing-ground scheme also presents a method of avoiding collision in the air, which is bound to happen if no arrangements are made, and it would be very simple for an outward pilot to keep to the right and an inward pilot to keep to the left. Then, again, once you accept this proposition, even crossing the Atlantic becomes feasible. What is to prevent us having a ship, not necessarily anchored, but always cruising, say, every 50 miles from the Azores to Newfoundland? On the North Sea you will find the pilot cutters which are there from one end of the year to another, with the pilots awaiting inward and outward bound ships. Compared with the enormous scheme a mail between London and New York will present, the cost of 10 or 20 ships (which may be simply fixed lightships if feasible, or small cruising ships if necessary) is infinitesimal.

"I understand that the number of week-end telegrams, 4s. 6d. for 25 words, which are not able to be sent because the lines are so full, is enormous, but this is nothing compared to the tonnage of mails which would be available if they could be carried from London to New York and *vice versa* in two days.

"It is harking back to a very long time ago to the Pony Post in America, but in Mark Twain's *Roughing It* you will find an account of letters being carried 2,000 miles in eight days at the cost of £1 per letter. This really is very much the system of an aeroplane mail, but at a commercial rate and enormous speed. The rider galloped night and day, winter and summer, 10-mile stages, using a fresh pony for every stage. They were apparently, even in those days, streamlined—that is to say, the mail packets were fitted to the rider's body. Again, like an aeroplane, they carried no extra weight, they used a racing saddle, and wore light shoes or none at all. The letters were written on paper as thin as gold-leaf, and thus bulk and weight were economised. Eighty pony riders were in the saddle night and day, stretched in a long procession from Missouri to California, forty flying eastward and forty westward, and using amongst them four hundred ponies. So will the Aeroplane Mail soon traverse the world in stages, some being stations, others being passed over.

"I will presume that you have now accepted this principle, and it is quite possible to indicate on a map of the world those routes which we assume will be covered with 10-mile landing grounds. Once assuming that, I believe you will accept my previous figures on commercial aeronautics as a perfectly feasible proposition. You will see then what an enormous thing commercial aeronautics represents, and what a revolution in speedy transit. Ceylon becomes 2¾ days from London, Tokio 4½ days, Sydney 5 days, Cape Town 3½ days, Vancouver 3 days, and so on; and once you have accepted the premises on which I started you will admit that I am only putting before you propositions which are perfectly easy to carry out.

"We should see on this map I have mentioned Timbuctoo, which sounds the most improbable place that anybody would wish to arrive at, but, strange to say, it is one of the places where an aerial service is already projected by the French, which really affords a very good instance of the use of the aeroplane. At the present moment it takes three to four months from Bordeaux to Timbuctoo, and owing to this the many officers employed spend half their time going and coming. The cost of this journey at present is £120, and it is estimated by a friend of mine in the French Government, who has given me this plan, that it could be done by aeroplane for

£100 per journey, and taking it in easy stages it would only be a matter of days instead of months.

"Instances in the Overseas Dominions, where not yet developed, we shall find in hundreds, where the aeroplane can be used, but to take only one example, look at Australia and note the present railway lines there. You will see that an aeroplane service on each side of any of these lines of 50 to 100 miles would certainly mean the establishment of a great many small townships, which eventually, when big enough, will of course have their railway. This, coming down to pounds, shillings and pence, presents an absolutely commercial aspect, as can easily be seen. A passenger from the township to the railway, or *vice versa,* can be carried profitably at four-pence per mile, which is a little more than first-class fare in this country. Mails and goods can be delivered at 2½d. per lb., and this applies to all the Overseas Dominions.

"One point I should like to disabuse every one on at once is the discomfort of an aeroplane. At the present time it is not, of course, suited for carrying a large number of passengers, but I have gone carefully into this problem with my drawing office, and, allowing for the reduction in speed the alterations will necessarily make, we find that it is perfectly easy to design a comfortable cabin in which passengers would be quite as much at their ease as by any other method of transit. When, therefore, you come to the discomfort of a shaky train, the dirt, and the annoyance of changing from train to boat and boat to train, etc., you will find that the comfort of the aeroplane is easily superior to the discomforts one goes through on an ordinary journey to-day.

"Now, I should like to explain that my figures and fancies set forth here have been based on present-day machines, but we must take into account that the aeroplane has only really been encouraged since war began and for war purposes. It is therefore fair to assume that the aeroplane has developed along entirely wrong lines from a commercial point of view, and the present design is wrong (thinking commercially) for the following various reasons:—

"1. Excessive climb demanded in a fighting machine, and power thrown away to obtain this.

"2. Excessive attention devoted to visibility, gun positions, etc.

"3. Excessive strength for fighting manœuvres, etc.

"The present unpleasant features of an aeroplane—*i.e.*, noise, oscillation, cold, cramped positions, are all due to war design, and can all be eliminated in a passenger-carrying aeroplane without reducing this speed very much, but only by sacrificing climb, visibility, guns, etc.

"In criticising the cost of running an aeroplane service and comparing it with train service or ships, one ought to consider how very unpractical and useless the first trains or ships were, and how exceedingly unpleasant travelling in them must have been. Passengers in the first train, I believe, were just as cramped as they are to-day in an aeroplane. The oscillation was greater, they were covered with smoke and cinders, and the speed was limited to the rate at which a man could walk in front with a bell.

"The early ships were equally unstable, and it was a very doubtful point when a ship set out when it would arrive at its destination, if ever.

"If one reads any of the accounts of the early voyages, one is struck by the fact that very frequently they set out from a place and returned six months later, having met adverse weather, and it was the custom to say Masses for anybody who thought of doing anything so hazardous as going a sea voyage.

"The safety of the present steamship transit, I would submit, is due in the first place to engine development; also to the fact that every country has spent millions of money in harbours, lighthouses, docks, shipyards, etc., etc., and for an aeroplane service exactly the same steps will have to be gone through to ensure success for the commercial aeroplane.

"Looking a good deal ahead one point occurs —*i.e.,* that the geography of the upper air is at present quite unknown, and assuming the large aeroplane comes into use with reliable, powerful and compact engines, it is reasonable to suggest that steady air currents, etc., may be found which would enable the trip to be made at a much greater speed and with much greater power than is at present even anticipated, and consequently much greater economy.

"Now all I have been able to do is to give you something to think over, something to digest; but I hope I have proved that flying has come to stay, and must from an Imperial point of view be supported in every way. Mail services, as I have shown you, can be established commercially; business men can use the aeroplane commercially for many purposes, and for pleasure nothing can beat it. I have projected a somewhat imaginative picture of the future—something of what an aerial service will look like, and the last thing I have to say is this. Remember that we live on an island; remember that we have always depended on the sea for our protection; and last, but not least, remember that we are an Empire. On all these points it is necessary to maintain a huge aerial fleet, and the proper support of commercial aeronautics will enormously assist these ends. *This* time we *must* be first."

# GREAT BRITAIN MISTRESS OF THE AIR AND SEA

# CHAPTER XII

## GREAT BRITAIN MISTRESS OF THE AIR AND SEA

SENSATIONAL writers have occasionally attempted to harrow the feelings of their readers by a description of what would happen to any country where a powerful enemy, having prepared a huge air fleet in secrecy, suddenly launches an attack against undefended and unprepared towns and cities. No very vivid imagination is needed to visualise the effect ten thousand of the biggest British bombing machines of the 1917 type, handled by experienced pilots and observers, would have on German peoples if such a fleet could be put into action while the Germans themselves owned not a single aeroplane. But this sort of thing is frankly quite impossible. Nations have much in common with sheep. They follow set leads in very curious manner, and as it is quite impossible for any one nation to build and test sufficient machines to give even local command of the air without news of what is going on reaching rival Governments, it is next to impossible to secure sudden aerial supremacy. It does not follow, however, that when a Government has news of the preparations of a rival immediate and suitable protective measures are at once put in hand; far from it, alas! On the other hand, all the big war surprises in the world's history have been short-lived, and to every new attack there is somewhere or other a good reply, the trouble usually being to find and apply the defensive in time for it to be of service. Indeed, the biggest military surprise of the world has been witnessed by the present generation, who saw Germany spring her huge military machine, equipped with its giant howitzers, long-range guns, caterpillar tractors, poison gas, airships and other frightful weapons on a practically unprepared world in the great and ill-fated bid for world supremacy. Most of the other weapons developed during the war have also depended for their success very largely on the element of surprise. It is possible to use new weapons entirely or old ones in a new way. As an instance of the former the big German howitzers, and of the latter the use of the tanks in the famous Cambrai battle of the Third Army during the concluding days of November, 1917. There are still to be found those whose opinions are worthy of respect who are firm in their belief that the secret development of some new and powerful type of aeroplane may, in the event of future wars, give quick and crushing victory in the minimum of time to the nation using it. Other authorities are disinclined to accept this theory. Experience during the Great War, on the whole, bears out the opinions of this latter school.

There are idealists and objectors to warfare still nourishing the hope that by international agreement the use of aircraft and the training of pilots may be abandoned in the peace that is to come. Were aircraft in its broadest and best sense simply a weapon of war, every reasoning man would give his support to the proposal, but the plain truth is that one of the greatest discoveries ever made for the benefit of man has been perverted in its use and, possibly, has in consequence given the slight thinker an excuse to urge its complete suppression. There is no talk of preventing war by the abolition of railway systems because armies can be moved with rapidity where a good system of strategic railways exists, and if any country prove so idealistic as voluntarily and " off-its-own-bat," so to speak, to forego the use of aircraft and railways, that country has only itself to blame for what happens to it in the case of an attack by any other country which looks on the matter in rather a different light. If Russia, for instance, elects to play a lamb-like part in the war, not all the efforts of the combined Allies could save her from being ravished by German aircraft.

If this argument be granted, undisputed command of the air cannot be secured either by vast and open preparation of an air fleet overwhelming in number or by the sudden launching of greatly improved and powerful machines. England cannot build fifty times as many aeroplanes as Germany without stirring up trouble, because to do so would imply a direct threat against Germany; nor would it be unreasonable for other nations to assume that such an overwhelming fleet may suddenly be launched against them, and, naturally, other aircraft programmes would be adjusted to preserve the balance. The present Great War, however, is being fought with a view to the future reduction of armaments, and if it fail in this respect, if nations are forever to continue spending the bulk of their revenues on armament, then the day of a reasoned world is over, and it is of little moment as to how or why aircraft is developed. It is more than possible that armaments of the future will be based on the minimum requirements needed by any country to resist sudden and unexpected attack, and the relative numbers of the air fleets maintained by each nation will be regulated by the relative power and importance, commercially and otherwise, of such nations. Great Britain, because of its far-flung Empire, its geographical position, its big overseas carrying trade, its coastline, and other causes, will quite logically develop an air fleet which, in numbers and power, will bear the same relation to, say, the Portuguese air fleet as the present British Navy bears to the Portuguese Navy. The naval analogy, however, cannot be applied throughout, and the United States will be in a different position so far as aircraft is concerned than was the case when naval power only was in question. The small but highly efficient United States Navy was considered quite strong enough to defend the country in case of threatened naval attack by any European Power. Wireless would have kept the American naval authorities informed of the advance of any enemy fleet, which, even in the event of its reaching the American coastline in safety, could at the worst only have attacked by bombardment the undefended cities along the coastline, and even the power to do this was regulated very largely by the coaling stations at the command and in the possession of the attacking Power. Any European navy attempting to convoy an army to the United States would have been comparatively easy prey to the United States Navy, which need not have risked action in force, but could have gained a comparatively easy victory by cutting the lines of communication. Not all the navies of Europe could have maintained lines of communication sufficient to maintain an army of any size in the United States, while the latter country itself retained any semblance of naval power. Again the possibilities of the United States in shipbuilding could not safely have been ignored by any European country in the pre-aircraft days, and therefore the Americans, despite their wealth, trade and commerce, were in the happy position of leaving Europe to stew in its own juice so far as concerned the crippling burden of armaments, both naval and military.

Aircraft has changed this, and in the future the United States of America will find it necessary to maintain an air fleet more in accordance with the position of the country as a leading Power. For these reasons, well-informed authorities hold the view that aerial strength in the future must inevitably remain in the hands of Great Britain and the United States.

A satisfactory system for the regulation and control of aircraft cannot be organised in a few days, weeks or months. Naval laws have come into being as the results of some hundreds of years of fighting and diplomacy, and are even to-day in a state of constant flux, as the Declaration of London—to take only one instance—

demonstrated. When aircraft comes into universal use there will be many questions to be solved. There will be the question of the ownership of the upper air. Will all air be international as are the high seas, or will each country forbid the aircraft of other nations to use its air unrestrictedly? Every nation has, of course, to the best of its power recognised and preserved the inviolability of that narrow strip of water surrounding its coast known as the three-mile limit, but very obviously there can be no corresponding strip of air marking a hard and fast line which no foreign power may invade without risk of war. And all sorts of questions and queries arise if each country reserves to itself its own "upper air." In case of war neutrality would be practically unknown and impossible if the rights to its own upper air were retained by each nation. How, for example, could the unintentional infringement of neutral air be prevented, only by sending up patrols to drive off or attack the infringing craft? And were this done a state of war would rapidly follow. On the other hand, if an apology were accepted, what is to prevent the neutral nation from being charged with favouring and aiding one of the belligerent nations? Further, again, to this there is, so far as can be seen, no means of preventing huge aerial fleets using the upper air of any neutral country in heavy weather should it be decided to run the risk of detection.

In the future, when things have sorted themselves out to some extent, when each country has its own recognised alighting grounds, complete with customs, repairing sheds, replenishment depots and so on, together with a complete system of aerial patrols, some of these questions may be nearer to solution, but before that time comes the question of customs' evasion, smuggling and spying from the air will need to be solved. No doubt the aircraft of each nation will be called on by international agreement to bear some distinguishing mark, and very possibly flying limits both in regard to speed and height will be established for universal use. Further complications will arise in regard to private property in the country flown over and in regard to forced landings. Obviously some agreement must be reached as to liability to growing crops, property and life in case of forced descent or accident in the air, and until some satisfactory solution is reached, flying over big cities at any rate will be restricted. As the law in most countries at present stands, an action for damages can be brought against motor-car owners, public companies, railways, steamship owners and other persons and concerns causing damage to private property or peoples engaged in their lawful vocations, but difficulties can be foreseen in bringing an action against the owner of any particular aircraft which may have been flying at a speed of 120 miles an hour at a height of 10,000 or 15,000 feet and possibly at night, who by accident drops, say, a spanner and causes injury to property or persons on the ground below. Almost it would seem as though no satisfactory system to deal with these and other matters could possibly be evolved, but with the passing of time and with greater experience no doubt order will be evolved out of chaos.

No one dreams to-day of prohibiting the use of motor-cars, and yet although these vehicles are distinctly marked and numbered and registered with local authorities, it is still possible for an unscrupulous driver to cause damage to lives or property and to evade detection and punishment. Few systems are perfect in this world and mankind, it would seem, must be content with the nearest approach to perfection possible. The person with vivid imagination is often enough very one-sided in his imaginings and sees only the dangers and difficulties following on any great development. In the use of aircraft he does not see or will not admit that before the first million aeroplanes can be put into general service throughout the world, many thousands of improvements will almost automatically have been made with a view to lessening chances of accident and damage. He asks that the improvements all be made beforehand, an impossible solution.

Colonel Lord Montagu of Beaulieu, C.S.I., F.R.Met.Soc., A.M.I.E., who is recognised the world over as an authority on all matters relating to motor-cars and aeroplanes, and who has been so kind as to write a foreword to this present work, developed some exceedingly interesting theories in his lecture called "The World's Air Routes and their Regulation." He is of the opinion that for some time to come flying will be more easy over the land than over the sea owing to the existence of well-organised landing places at every ten, fifteen or twenty miles. As an average gliding angle of an aeroplane with the engine shut off is 1 in 8, it would be necessary in order to ensure against disaster in case of engine failure to provide landing places sixteen miles apart, assuming that the majority of the flying was done at 5,000 feet. Commercial and financial interests will have greater bearing on the height and speed of aircraft in the future for, obviously, no machine will fly a mile an hour faster or a foot higher in altitude than is financially worth while, and wind currents will be of supreme importance to air transport companies, both as a means of increasing speed and economising fuel, just as the trade winds have, since the earliest days of navigation, been taken full advantage of by experienced mariners. The upper air has not been explored and investigated so thoroughly as the oceans, but there are well-defined and persistent air currents already known of which will be of great assistance to aerial navigation. The importance of these currents can hardly be overestimated, for a favourable 30-mile wind would add 1,440 miles in every 24 hours' continuous flight, while an unfavourable wind of the same velocity would naturally reduce the day's mileage by a similar distance. Because of this it is argued that future air routes will not take the most direct course between the respective countries and continents, the existing air currents being for the most part the deciding factors, and where these can be taken advantage of longer mileage is a matter of comparative indifference.

It is 1,800 miles from a point in County Kerry in Ireland to St. John's, Newfoundland, and assuming that a flight began from the latter place with a 30-mile westerly wind behind it, the aeroplane itself being capable of a speed of 80 miles per hour, the actual speed developed would be 110 miles an hour, and St. John's would be reached between 16 and 17 hours later. With an unfavourable wind, however, the actual flying speed of the aeroplane in relation to the earth's surface would be 50 miles per hour only, and the journey, therefore, would take 36 hours—more than twice the other time.

Because of these facts it may be advisable to have alternative air routes, and in some states of the atmosphere to fly to the North American Continent *via* Iceland and Greenland, and in others to fly *via* France, Spain, Portugal and the Azores, because of known and existing air currents. Lord Montagu argues that the first great world routes to be regularly organised will be the overland routes, and he notes that the longer the distance the more remarkable the time saving.

In support of his case Lord Montagu presents two alternative routes to India, and beyond India to Australia and China, the fastest pre-war time for reaching these places being about 15 and 30 days respectively. The northern route is possible only if some international arrangement in regard to the use of the air over foreign countries be reached, for it involves flying over five other countries and gives a distance from Peshawar of 3,600 miles and from Australia of about 7,000 miles. The alternative route would be all-British and would pass wholly over the sea and the land of the British Empire and the three-mile sea limits round it. Very probably, however, arrangements could be made with France, Italy and Portugal for the use of landing stations in those countries. This second route, *via* Gibraltar, is about 1,600 miles longer, giving a total of 5,200 as against 3,600 miles. Assuming that only flying by day will be advisable for some considerable period to come, each day's flight is limited to 10 hours, and, at an average speed of 120 miles an hour, 1,200 would be covered between dawn and sunset. Even by thus resting at night, however, the times taken in comparison with steam and rail services would be greatly reduced; in the case of India by at least 11 days and in Australia by 23 or 24 days.

Possibly the first continuous services will be those devoted to the carriage of mails. Passengers would transfer to different aeroplanes piloted by fresh pilots at each stage of the journey, as a guard against undue fatigue and mechanical breakdown, and probably pilots will specialise in the air currents and other conditions prevailing over their particular stages.

Lord Montagu so arranges the stages of the two suggested routes to India:

## I.—Southern Route to India.

### *First Day.*

| MILES. | | | TIME. |
|---|---|---|---|
| — | Croydon (London) | dep. | 7 a.m. |
| 625 | Marseilles | arr. | 12.30 noon. |
| | | dep. | 1.30 p.m. |
| 485 | Naples | arr. | 6 p.m. |
| 1,110 | | | |

### *Second Day.*

| MILES. | | | TIME. |
|---|---|---|---|
| — | Naples | dep. | 7 a.m. |
| 640 | West Coast of Crete | arr. | 12.15 noon. |
| | | dep. | 1.15 p.m. |
| 485 | Alexandria | arr. | 5.45 p.m. |
| 1,125 | | | |

### *Third Day.*

| MILES. | | | TIME. |
|---|---|---|---|
| — | Alexandria | dep. | 7 a.m. |
| 580 | Jof | arr. | 12 noon. |
| | | dep. | 1 p.m. |
| 460 | Basra | arr. | 5 p.m. |
| 1,040 | | | |

### *Fourth Day.*

| MILES. | | | TIME. |
|---|---|---|---|
| — | Basra | dep. | 7 a.m. |
| 575 | Bandar Abbas | arr. | 12 noon. |
| | | dep. | 1 p.m. |
| 680 | Karachi | arr. | 6.30 p.m. |
| 1,255 | | | |

Total distance, 4,530 miles.
39 hours 15 minutes actual flying time.
83 hours 30 minutes total time on journey.

II.—NORTHERN ROUTE FROM INDIA.

*First Day.*

| MILES. | | | TIME. |
|---|---|---|---|
| — | Peshawar | dep. | 7 a.m. |
| 600 | Bokhara | arr. | 12 noon. |
| | | dep. | 1 p.m. |
| 620 | Gurieff (Caspian Sea) | arr. | 6.15 p.m. |
| 1,220 | | | |

*Second Day.*

| | | | |
|---|---|---|---|
| — | Gurieff | dep. | 7 a.m. |
| 600 | Lugansk | arr. | 12 noon. |
| | | dep. | 1 p.m. |
| 610 | Tarnopol | arr. | 6 p.m. |
| 1,210 | | | |

*Third Day.*

| | | | |
|---|---|---|---|
| — | Tarnopol | dep. | 7 a.m. |
| 600 | Leipzig | arr. | 12 noon. |
| | | dep. | 1 p.m. |
| 600 | Hendon (London) | arr. | 6 p.m. |
| 1,200 | | | |

Total distance, 3,630 miles.
30 hours 15 minutes actual flying time.
59 hours total time on journey.

Very obviously some system must be arranged for the separation of the air traffic in the various levels, and a sound and generally accepted principle for the regulation of air traffic as it is at present understood is that slow-speed planes should use the lower and high-speed machines the upper levels of the air. Whatever arrangements are made, however, will be in the nature of compromise, for each nation and every interest will advance its own views, and as it will be impossible to agree to all there must be quite a lot of give and take. A reasonable assumption is that no flying can take place below 2,000 feet except by permission of the owner of the land flown over. Between 2,000 and 4,000 feet should be preserved for the use of silent aircraft of a speed less than 80 miles per hour. From 4,000 to 6,000 feet might be used by silent aircraft of speeds between 80 and 120 miles per hour. From 6,000 to 8,000 feet for aircraft having speeds greater than this. From 8,000 to 10,000 feet could be reserved for Government aircraft; and above 10,000 feet to be international.

The intense cold at high altitudes, not to mention the danger to persons of weak hearts and constitutions caused by decreased atmospheric pressure at great heights, will, for the most part, keep passenger traffic at the lower levels. The police, the postal service, naval and military machines will almost, as a matter of course, rise to the higher levels for obvious reasons, and, of course, rules must be drawn up for meeting and overtaking and also there must be some standard, such as Lloyd's, by which a machine may be judged for performance and strength before it is licensed to take the air.

Lord Montagu suggests that the generally agreed code of buoys and marks for defining sea channels should be imitated so far as practical, although, of course, some lighthouses will be required to throw their rays in a vertical instead of a parallel direction, and at sea a system of large buoys may be necessary, while our ideas as to size will need revision, for a circle 100 yards in diameter unless it be very distinctively marked or illuminated seems very small when flying at a height of 10,000 feet. For daylight, flying routes may conveniently be defined by ground marks on the right-hand or starboard sides, all routes from west to east could be indicated by marks having a white ring and a black centre, while the port or left-hand side could be indicated by a black-and-white checker pattern, landing places being marked differently. At night the routes would be defined by continuous white lights on the starboard side and red-and-white alternating lights on the left side. Prohibited areas must, of course, have a very distinctive mark and, additionally, other devices must be thought out for the purpose of assisting the pilot to make a landing. The aerodromes may be circular in shape, rise to a considerable height, and have a flat top, a sort of truncated cone, the particular advantage of this being that an aeroplane, landing at the foot of the hill, must needs travel uphill against the force of gravity and, when starting off again, would, running downhill, have its speed increased by the force of gravity and could thus take the air more conveniently. Indicators would show the direction and the velocity of the wind during the day, and some system of illuminated lighting, such as the Germans used even in pre-war days, would be needed to help the pilot to alight at night. Naturally the navigating instruments aboard the aircraft would be used for route finding between the various aerodromes and landing places, for, obviously, it will be impossible to sprinkle the whole surface of the globe with route marks, and for long journeys across the oceans or the more remote countries the pilot will have to guide himself by compass and well-defined and natural landmarks. Air maps will, of course, be printed as a further assistance. In addition to the identification marks painted on the aircraft itself, each machine will be required to carry navigation lights for night flying, and possibly also so arrange its lighting that the distinguishing identity marks are also visible at night, and although in the future the majority of pilots will be no more inclined to waste fuel than car drivers are to-day, it will be necessary, if the agreed-on flying levels are to be generally recognised, to adopt some system of distinctive ground markings for the pilot's information in regard to the contour of the ground over which he is flying. In hilly countries particularly this is important.

Lord Montagu finally concludes that there are three points of importance to be borne in mind when considering the future of aerial navigation. Firstly, that so soon as the war is over and the nations have had time to readjust themselves somewhat there must be both national and international laws for the regulation of flying. Secondly, oversea and over-Continental routes must be defined in the interests of the whole world. Thirdly, the winds of the world, instead of being a drawback to flying, will, if properly used, be a very great assistance.

It will, of course, be necessary for the great nations to give a lead to the smaller countries in this matter of international aerial navigation, and for the reasons already indicated it will fall to the lot of Great Britain and the United States to assume great responsibility at the conferences which must come. No reasonable man would lodge a claim that the mastery of the seas held by Great Britain for a hundred years has been without fault or flaw, but, fortunately, the difficulties fronting this country in this respect have been better understood and appreciated by other nations, who have benefited both commercially and financially by Great Britain's sea police, than some of those people in this country, who are never so happy as when acclaiming the virtues of other nations and decrying their own country, are aware of.

The mastery of the seas has its powers and privileges and its limitations, and it was as much as anything else because Great Britain did not appreciate the limitations in full that one of her proudest colonies broke away and acclaimed its independence, after supplying a very forcible illustration to Great Britain that mastery of the seas did not confer world dominion, as some of her statesmen were inclined to believe. Britain learned the lesson that Germany is learning to-day a century and more ago, and there is no doubt that the world in general will benefit and rise to greater heights in every way, just as the United States benefited and rose to power and greatness.

There may be some inclined to argue that a great aerial fleet devoted to the pursuit of commerce confers on any country an immense military advantage in that the commercial aircraft could be transformed and put to military use in case of war. It may be so. The commercial aircraft, however, could be used only for police and patrol purposes, just as so many thousands of lighter Allied sea-craft are used to police the seas to-day. Some slight means of attack or defensive may be given at a corresponding reduction in their efficiency, but aircraft of this sort would stand no more chance against the specialised fighting aeroplane of the future than does the steam trawler, armed with a three-inch popgun, against the light cruiser or torpedo boat in the present war. The last few years have shown beyond dispute that the fighting aircraft of the future must for the most part consist of highly specialised units, built for speed, bomb-dropping, photography, observation, fighting against other aircraft or other special purposes, and as design will enter very largely into the building of future commercial aircraft, the two things will be vastly different, and beyond the fact that both types use the same element and the same source of power, there will be little in common between them. Commercial aircraft must be designed with an eye to first and running costs. An extra speed of 10 miles per hour will not be given at an excessive expenditure in fuel, and although there will be a few fast passenger craft, corresponding in some degree to the crack passenger liners of to-day, the bulk of the commercial aircraft will be stodgier machines engaged in a humdrum round of commercialism, and corresponding for the most part—apart, of course, from size and carrying capacity—to the tramps, cargo carriers and coasting ships of the present period. It is for these reasons that Great Britain and the United States can and must, with a clear conscience to themselves and the other countries of the world, assert their rights, each in their own spheres, to aerial supremacy in the days of peace to come.